ENGINEERING:

An Illustrated Weekly Journal.

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ROCHESTER.
Steam & Crude Oil Road Rollers, &c. 2581

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ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 19.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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See half-page Advert. last week and next week. 2087

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Thos. Piggott & Co., Limited,
BIRMINGHAM. 2530
See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
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Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
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SPECIALISTS
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 33.

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PASSENGER AND CARGO STEAMERS.
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Worm Wheels cut up to 13 ft. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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PRESSURE AIR, STEAM
For Boilers of all types.
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Naval Outfits a Speciality,
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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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GEAR WHEELS up to 10 ft. diameter.
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Special designs only.
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GENERATING SETS, Totally Enclosed, Three Crank Self-Lubricating Engine, with Complete Condensing Plant, by Allens, Pipes, Valves, Oil Separator, &c., complete.
Admirably suited for Mining or other power transmission work.
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GENERAL CONSTRUCTIONAL ENGINEERS.
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Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 79. 2584

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
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REFRIGERATING PLANT. 1475
See Advertisement, page 49, Jan. 30.

Govan Engine Works,
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FOR SALE
IN WHOLE OR PLOTS.
GROUND extending to 42,672 square yards, and BUILDINGS thereon of Engine and Boiler Shops (lately belonging to Messrs. DUNSMUIR & JACKSON, Ltd.), equipped with Overhead Travelling Cranes up to 60 tons.
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MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
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LAND AND MARINE.
YARROW BOILERS. 2977

Matthew Paul & Co., Ltd.,
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See Full Page Advt., page 56, Jan. 30.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 10, Jan. 30. 8195

New 300 & 500 B.HP. M.A.N.
STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C.4. 2527

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."
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Five 25 H.P. Direct Current
MOTORS, by Thomas Parker. Four poles and interpoles. Shunt, with starting panel. Price £30 each. F.O.R. BOLTON.

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FOR SALE, CHEAP.
12 in. centres on 12 ft. gap bed. D.G., S.S. & S.C. With hollow spindle. 4-jaw chuck. Change wheels and countershaft. Price £90. F.O.R. BOLTON.
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Slitting Saws
AND SCREW SLOTTING CUTTERS.
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Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9336

The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

No. 0038 of 1925

IN THE HIGH COURT OF JUSTICE.
CHANCERY DIVISION.

Mr. JUSTICE ROMER.

IN THE MATTER OF THE STILL ENGINE COMPANY, LIMITED,
and
IN THE MATTER OF THE COMPANIES (CONSOLIDATION) ACT 1908.

Notice is Hereby Given that

by an Order dated the 3rd day of February, 1925, the Court has directed separate Meetings of

(1) The Holders of the 8% Debentures issued by the above-named Company.
(2) The Holders of the 'A' Shares, and
(3) The Holders of the Ordinary Shares respectively of the said Company to be convened for the purpose of considering, and if thought fit approving (with or without modification) a Scheme of Arrangement proposed to be made between the said Company and the Holders of the 8% Debentures the Holders of the 'A' Shares and the Holders of the Ordinary Shares respectively of the said Company and that such Meetings will be held at Winchester House, Old Broad Street, in the City of London on Wednesday the 18th day of February, 1925, at the times below mentioned, namely:

The Meeting of the 8% Debenture Holders at 11.30 o'clock in the forenoon,
The Meeting of the 'A' Shareholders at 11.40 o'clock in the forenoon or so soon thereafter as the preceding Meeting shall have been concluded,
The Meeting of the Ordinary Shareholders at 11.50 o'clock in the forenoon, or so soon thereafter as the preceding Meetings shall have been concluded,

at which place and respective times all the aforesaid 8% Debenture Holders, 'A' Shareholders and Ordinary Shareholders are respectively requested to attend.

A copy of the said Scheme can be seen at the Registered Office of the Company situate at No. 7, Princes Street, Westminster, in the County of London, between the hours of Ten a.m. and Two p.m. on any week-day prior to the day appointed for the said Meetings.

THE said 8% Debenture Holders, 'A' Shareholders and Ordinary Shareholders may attend the Meetings of any Class of which they are Members and vote thereat either in person or by proxy but all forms appointing proxies must be deposited with the Company at its Registered Office situate as aforesaid not later than Eleven o'clock in the forenoon on Monday the 16th day of February, 1925.

FORMS of Proxy may be obtained from the Secretary of the Company.

THE person appointed to act as Proxy must be a member of the same Class as the appointor.

IN the case of joint holders of any Debenture or of any share the person whose name stands first in the Register in respect thereof shall alone be entitled to vote in person at the Meetings. In the case of joint holders voting by Proxy the forms of proxy must be signed by each of the joint holders.

THE Court has appointed Major CLEMENT HAUGHTON LANGSTON CAZALET, D.S.O., or failing him WILLIAM STEPHEN EYRE to act as Chairman of the said respective Meetings and has directed the Chairmen to report the results thereof respectively to the Court.

THE said Scheme of Arrangement will be subject to the Subsequent approval of the Court.

DATED this 3rd day of February, 1925.

SLAUGHTER & MAY,
of No. 18 Austin Friars in the City of London Solicitors for the above-named Company. H 122

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition. — For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, invites

Tenders for:

GIRDER BRIDGEWORK.

Tenders due on the 20th February, 1925.
Tender Forms obtainable from above. H 138

COUNTY BOROUGH OF PORTSMOUTH.

SOUTHSEA STORM WATER DRAINAGE.

PUMPING INSTALLATION.
The Council invite

Schemes and Tenders for the

SUPPLY, DELIVERY and ERECTION at the Burgoyne Road Pumping Station, Southsea Common, of TWO ELECTRICALLY-DRIVEN CENTRIFUGAL PUMPS complete with all works in connection therewith, and for the Maintenance of the whole in thorough repair for twelve calendar months from the completion thereof.

Copies of the General Drawings, Conditions and Specification under which Tenders are invited, may be obtained on application (accompanied by the sum of £3, which will be refunded on the return of the documents within seven days or after the receipt of a *bona fide* Tender accompanied by the documents required) to Mr. ARTHUR W. WARD, the Borough Engineer, Town Hall, Portsmouth, from whom any further particulars may be obtained.

Each Tender must be accompanied by Drawings and detailed Specification descriptive of the Scheme submitted by the person tendering and the particular design of pumps, electric motors, etc., he proposes to use.

Tenders, marked "Tender for Pumps, Southsea Drainage," are to be sent in on the form supplied, and must reach the undersigned not later than Ten a.m. on Friday, the 20th February, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

F. J. SPARKS,
Town Clerk.

The Town Hall,
Portsmouth.
24th January, 1925. H 35

COMPETITION FOR A HIGH BRIDGE ACROSS THE HARBOUR OF COPENHAGEN.

THE MUNICIPALITY OF COPENHAGEN
hereby invites to partake in an

International Competitive

PRELIMINARY DESIGN for a HIGH BRIDGE across the Harbour of Copenhagen.

The Municipality of Copenhagen places an amount of 35,000 Kr. to the disposal of prizes. There will be distributed three prizes, the size of which will be fixed by a committee, composed of members of the town council and technical advisers selected by the municipality of Copenhagen, the Danish Engineering Association, and the Association for the Academical Architects.

The greatest prize will at least be 15,000 Kr.

Program, with appendix in Danish and English, will, from the 1st of February, 1925, be supplied at the Office of the City Engineer, adr.: Stadsingeniørens Kontor, Raadhuset, Copenhagen B, by payment of a deposit of 100 Kr.

The deposit will be repaid when the Competition projects are adjudicated, or when the received papers, etc., in beforehand are returned in undamaged condition.

The Competition projects have to be submitted to Stadsingeniøren, Raadhuset, Copenhagen, before the 1st of September, 1925, Twelve o'clock.

All the competition designs submitted will, after the adjudication, be exhibited before the public in the Town Hall, Copenhagen.

THE MUNICIPALITY OF COPENHAGEN.
H 92

D. BLACK & COMPANY, LIMITED (In Liquidation), Engineers and Electricians, Washington Street, Govan.

The Subscriber invites

Offers for the Purchase of the

BUSINESS of GENERAL ENGINEERS, MACHINE TOOL MAKERS and ELECTRICAL ENGINEERS, etc., carried on by D. Black and Company, Limited (In Liquidation) and at Washington Street, Govan, Glasgow, including the whole Buildings, Travelling Crane, Machine Tools, Stock, etc. The Buildings are modern, and occupy one of the best sites in an industrial centre. They cover an area of 1400 square yards or thereby and adjoin the Foundry of Messrs. Harland & Wolff in Helen Street. The Feu-duty is £18. The Machinery is modern and the ground permits of an extension of the present Buildings. The Office section is up-to-date and consists of Counting, Drawing Office, Private Rooms, Garage and Lavatories.

The subscriber will consider offers for the Buildings and Machinery apart from the business. Orders to view the Works can be obtained from the Subscriber or Messrs. BIRD, SON & SEMPLE, 71a, West Nile Street, Glasgow. Sealed Offers, in writing, are to be lodged on or before Saturday, 21st February, 1925, with the Liquidator who does not bind himself to accept the highest or any Offer.

J. ALLISON, Jr., C.A.,
Liquidator.
219, St. Vincent Street, Glasgow. H 90

THE DUBLIN BOROUGH COMMISSIONERS
hereby invite

Tenders for the under-

mentioned requirements for six months from the 1st April, 1925:—

1. Bicycles, etc. 2. Bricks, Stoneware Sewer Pipes, Slates. 3. Broken Green Whinstone, Chippings, etc. 4. Caps, Hats and Overalls. 5. Cast Iron Pipes and other Castings. 6. Creosoted Paving Blocks. 7. Flags, Kerb, Lime, etc. 8. Galvanised Ware. 9. Iron Materials and Stores. 10. Leather, India Rubber Goods and Hose. 11. Oils Paints, Drugs and Veterinary requirements. 12. Portland Cement. 13. Plumbing Work. 14. Belting and Materials. 14. Public Lighting Requirements and Glass. 15. Ropes, Twine, Canvas, etc. 16. Sand and Aggregate. 17. Small Metal Castings. 18. Timber and Stores. 19. Weighbridge Maintenance. 20. Maintenance of Lifebuoys.

Specifications, Forms of Tender, and Conditions of Contract may be obtained at the Offices of the City Engineer, 28, Castle Street, on payment of One Shilling.

Standard samples of the articles specified may be inspected by Tenderers at the Municipal Workshops, Stanley Street, or in the Corporation Depots, as indicated in the Forms of Tender.

Sealed Tenders, endorsed "Tender for....." and addressed to the Dublin Borough Commissioners City Hall, Dublin, must be delivered not later than 12 o'clock Noon, on Monday, the 16th instant.

By Order,
JOHN J. MURPHY,
Town Clerk. H 111

BOROUGH OF KENDAL.

SEWAGE DISPOSAL WORKS.

PUMPING PLANT.

The Corporation invite

Tenders for the Provision and

INSTALLATION of an ELECTRICALLY DRIVEN PUMP with MOTOR, at Wattsfield Sewage Works.

Plan, Specification, Conditions and Form of Tender may be obtained on application to the undersigned, on or after Wednesday, the 4th instant, on receipt of a deposit of £2 2s. made payable to the Corporation, which deposit will be returned to each person or firm submitting a *bona fide* Tender and returning the Plan, Specification and Conditions.

Sealed Tenders, on the prescribed Form of Tender, to be sent to me, not later than Five p.m., on Wednesday, the 25th instant.

The Corporation do not bind themselves to accept the lowest or any Tender, and persons Tendering do so at their own cost.

F. W. OXBERRY,
Borough Engineer and Surveyor.

Town Hall,
Kendal, 2nd February, 1925. H 103

TYNE IMPROVEMENT COMMISSION.

MOTOR FERRY LAUNCH.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Construction

and DELIVERY in the Tyne of a MOTOR-BOAT, about 53 ft. long, 11½ ft. beam, speed not less than 7½ knots per hour, for passenger ferry service.

Copies of the Form of Tender, Conditions of Contract, Specification and Contract Drawing may be obtained from this Office on payment of a deposit of £2 2s., which will be returned on receipt of a *bona fide* Tender.

Tenders, in sealed envelopes, endorsed "Tender for Motor Ferry Boat," must be delivered at the undermentioned Offices addressed to the Chairman, Harbour and Ferry Committee, not later than Noon, on Thursday the 26th day of February, 1925.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvent Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
5th February, 1925. H 140

APPOINTMENTS OPEN.

CEMENT CONSTRUCTION ENGINEER.

Wanted, Experienced Cement

ENGINEER to superintend construction of new works, and if qualified, to take charge of management when works completed. Must have held similar position, and be a good draughtsman.—Apply, giving full particulars and salary required, to HORACE BOOTH & PARTNERS, 7, Victoria Street, Westminster. H 129

CITY AND COUNTY OF NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.
ATKINSON ROAD JUNIOR DAY TECHNICAL SCHOOL.
(Headmaster: Mr. JAS. W. BUCKHAM).

Required, for 1st May, 1925,

JUNIOR FORM MASTER; graduate qualified to take Mathematics and Experimental Science. Ability to teach Physical Training and Games essential. The Committee now pay the Burnham Technical Salary Scale, less five per cent.

Forms of Application (which may be obtained by forwarding stamped addressed foolscap envelope) to be returned to the undersigned *not later than FRIDAY, the 13th FEBRUARY*, 1925.

THOS. WALLING,
Director of Education.

Education Offices,
Northumberland Road. H 78

Wanted, for the Indian

ORDNANCE FACTORIES, an ASSISTANT WORKS MANAGER. Salary, Rupees 800 per mensem, rising by annual increments of Rs. 50 per mensem to Rupees 1000. The appointment is non-pensionable, but there is a Provident Fund to which Government contributes. Free passage to India is provided, and quarters, if available, at a rental not exceeding 10 per cent. of salary. An agreement for five years will be entered into in the first instance.

Candidates must be fully qualified Engineers, preferably with University degree in Engineering, or Diploma of Technical College of University status, and must have had at least five years' experience in First-class Works, preferably on machine tools construction or otherwise on plant maintenance.

Age limits 28 to 35 years.

The selected officer will be required to embark for India by end of February, 1925.

Applications should be submitted by 14th February at latest on forms to be obtained from THE SECRETARY, MILITARY DEPARTMENT, INDIA OFFICE, S.W.1.

Applications from candidates who are outside the limits of age, or do not possess the requisite qualifications, will be disregarded. H 119

District Engineer Re-

QUIRED by the GOVERNMENT OF PALESTINE, for the RAILWAY DEPARTMENT, for three years' service with prospect of permanency. Salary £E550-25-750 a year. Expatriation allowance of £E50 a year, plus a variable cost of living allowance at present fixed at £E27, plus 5% of the minimum salary. Free first-class passages. Candidates, aged 30 to 35, preferably single, must have had not less than five years' experience on British Railways on maintenance and construction work. Should be an A.M.I.C.E.—Apply, at once, in writing, stating age, whether married or single, and giving brief details of qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting at the top of application M/13366. H 120

Publicity Department of

large Electrical Company REQUIRES ASSISTANT with ability to prepare technical matter for publication. Engineering training and knowledge of printing routine an advantage. State age and salary required, and give particulars of previous experience.—Address, H 110, Offices of ENGINEERING.

Assistant Manager Wanted

for large Battery Works in the Midlands. Applicants (age not over 35) must be well educated and possess sound scientific knowledge, particularly of the chemistry and physics of the Lead Accumulator.—Address, H 143, Offices of ENGINEERING.

JODHPUR RAILWAY.
JUNIOR LOCOMOTIVE OFFICER.

Messrs. RENDEL, PALMER AND TRITTON, Consulting Engineers to the above Railway, are prepared to receive

Applications (by letter only)

from duly qualified Candidates for APPOINTMENT to the above VACANCY.

Applicants must be Public School men, about 25 years of age and unmarried, and must have a good technical education at some recognised Engineering College, and have passed the Associate Membership Examination of the Institution of Civil Engineers, or the Associate Membership Examination of the Institution of Mechanical Engineers, and have served either a pupilage or apprenticeship in Locomotive Shops in the United Kingdom, together with some drawing office experience. Preference will be given to one who has also had experience in the running department and/or of traffic working.

SALARY, Rs. 525 per calender month to commence, rising according to the scale laid down by Government of India Rules (approximately Rs. 50 per month annually). Salary commences on day of embarkation for India.

TERMS: A three years' agreement in the first instance, first-class free passage to India, and by rail to Jodhpur. The selected candidate will be required to pass a strict medical examination before final appointment.

Letters of application, giving the candidate's age, details of general and technical education, training and subsequent career (in chronological order) with dates, accompanied by COPIES ONLY of testimonials, Army Certificates, etc., should be addressed to Messrs. RENDEL, PALMER AND TRITTON, Appointments Department, 12-14, Dartmouth Street, Westminster, S.W.1, not later than the 13th February, 1925. H 71

Civil Engineering Assistant

WANTED, thoroughly experienced in the complete design of Stone and Steel, and Concrete Railway and Road Bridges.

Applications, stating experience and salary required, with copies of not more than three recent testimonials, to be sent.—Address, H 100, Offices of ENGINEERING.

Assistant Civil Engineer Re-

QUIRED immediately for Sudan, aged 23 to 27, unmarried; must have first rate technical qualifications and have had practical experience of levelling, making contour plans, designing works, etc. Irrigation experience desirable. Commencing salary about £500.—Write full particulars and copies testimonials to "C.T.", c/o J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C.4. H 107

Sudan Government Railways

REQUIRE the SERVICES of a DISTRICT ENGINEER. Age 26 to 32, preferably single. Starting rate of pay £E.480 to £E.540 according to age and qualifications. Candidates should possess A.M.I.C.E. degree or equivalent. Should have practical experience in railway construction and maintenance on British Railway. Progressive and pensionable post if retained. Free first-class passage. Strict medical examination.—Apply, by letter, with full particulars to THE CONTROLLER, Sudan Government, London Office, Wellington House, Buckingham Gate, S.W.1, marking the envelope "District Engineer." H 116

Mechanical Engineer

REQUIRED for position of responsibility in the Tropics to supervise the erection of new plant together with the running and maintenance of existing plant. Experience in the management of large oil mills or sugar factories and a knowledge of French desirable. Only applicants having first-class qualifications and of proved ability will be considered.—Applications should state fully experience, age (30/35), and salary expected.—Address, H 109, Offices of ENGINEERING.

AMMAN VALLEY JOINT SEWERAGE BOARD,

RESIDENT ENGINEER.

The Amman Valley Joint Sewerage Board invites

Applications for the Position

of RESIDENT ENGINEER in connection with the construction of the Board's Sewerage Scheme.

The work comprises a length of 8 miles of trunk sewer, with Sewage Disposal Works, and the person appointed by the Board will act under the direction of the Board's Consulting Engineer, Mr. H. B. WARD, Assoc. M. Inst. C.E., of Liverpool, and a Clerk of Works will be available to assist in the supervision.

Candidates should have had considerable experience in concrete construction, in particular, and must also have been accustomed to sewer laying and setting out and levelling for such work.

Applications, with copies of recent testimonials, stating fully the candidate's qualifications and experience, and salary required, should be sent to the undersigned on or before the 14th inst., in an envelope endorsed "Resident Engineer."

T. M. EVANS, M.A.,
Solicitor.
Ammanford, Carmarthenshire. H 88

Civil Engineers Required

by the GOVERNMENT of CEYLON for appointment as IRRIGATION ENGINEERS for three years in the first instance. Salary £500, rising to £900 a year by annual increments of £40 (£600 on attaining 30 years of age). Free passage provided. Candidates, preferably unmarried, age 26 to 31, must have had war service and passed the examinations to qualify for Associate Membership of the Institution of Civil Engineers or hold equivalent professional qualifications, and have had at least three years' practical experience on Waterworks, drainage, or harbour and dock works.—Apply, at once, by letter, stating whether married or single, age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting at the head of application M/13342. H 139

THE THERMAL EFFICIENCY OF POWER STATIONS.

By R. H. PARSONS, M.I.Mech.E., M.E.I.C.

(*Concluded from page* 94.)

WE will now turn to the consideration of the variations in the results of tests carried out on the same class of coal by the same observers with the same apparatus. In this case the personal errors and the instrumental errors may be regarded as reasonably constant. The discrepancies between the test results may be called "sampling errors," for they are due mainly to actual differences between the samples tested. The object of the first experiment to which we shall refer was to find out how closely samples taken from the same truck would agree with each other.

Columns A, B and C in Table V give the test figures obtained from three samples taken from one truck of coal. Every effort was made to collect samples which would be typical of the bulk. Equal portions of each sample were then thoroughly mixed together and the result of a test of the mixture is given in column D. The final column of the table gives the average of the first three tests for comparison. It will be noted that this average agrees very closely indeed with the test of the mixed sample. It is not safe to infer from this agreement that the mean of three tests of a quantity of coal will represent the bulk as accurately as if the whole quantity had been sampled. This, however, is a point to which we shall refer later. What the concordance of the last two columns does show is that a high degree of reliance can be placed on the individual tests. This being admitted, we have the disquieting fact that in three samples carefully taken from the same truck of coal, the ash may vary from 9·31 per cent. to 13·55 per cent. In other words one sample contained about 45 per cent. more ash than another, even according to the same analyst. Had different analysts or different methods been employed, the divergencies between the tests of the samples might, of course, have been greater. The obvious conclusion from the figures quoted in Table V is that to get a truly representative sample the whole of the truck must be sampled.

Fig. 1. CALORIMETER VALUES OF 51 SAMPLES OF SIMILAR COAL ARRANGED CONSECUTIVELY.

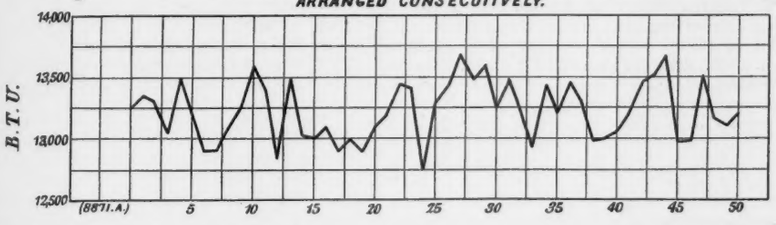


Fig. 2. CALORIMETER VALUES OF 51 SAMPLES OF SIMILAR COAL ARRANGED IN ORDER OF MAGNITUDE.

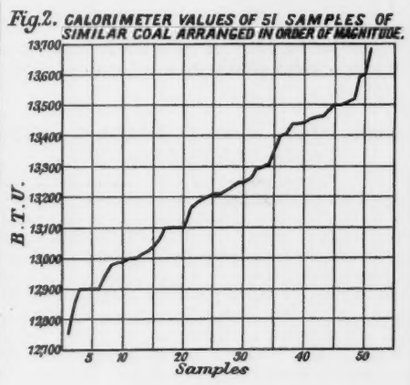


TABLE V.—*Victoria Pea Slack.*

—	A	B	C	D	Average of A, B and C.
Moisture, per cent...	4·25	4·6	4·25	4·37	4·37
Ash, per cent...	9·31	12·31	13·55	11·20	11·72
Calorimeter value, B.Th.U.	13,154	12,850	12,695	12,864	12,896
"As fired" value, B.Th.U.	12,595	12,259	12,156	12,302	12,337

We will now consider another form of test which throws light upon two matters, namely, the similarity between consecutive samples of the same fuel, and the extent to which the contents of trucks become mixed in their passage to the stoker hoppers. The tests were carried out at a power station in which the incoming truck loads of coal were tipped bodily into a hopper, whence the coal was drawn off, a ton at a time, into small wagons which were dumped into the boiler-house hoppers. The mixing in the ordinary sense of the word would be considered good. In considering the results, however, it must be borne in mind that no special pains were taken to ensure anything like an intimate mixture. The tests referred to are given in Table VI.

Tests A and B in Table VI were taken on the same quality of coal as was dealt with in Table V so that the results may be usefully compared from the point of view of uniformity of fuel supply. Each of the five groups of tests in Table VI refers to tests made on two different truck loads, the third test of the group being that made on the mixed coal at the stoker hoppers. The mixture is evidently far from complete, for in only one group, namely, Group B, does the ash content of the mixed fuel fall within the limits of the ash content of the individual trucks, and only in Groups B and E does the calorimeter value fall within the corresponding limits. The rise of moisture in the third or "mixed" test of Group A is due to the fact that the fuel was wetted before burning. The same practice was followed in connection with the fuel tested in Group B, but as there is no rise of moisture in the mixed fuel it would appear that the wetting was less uniform than had been desired. Comparing the first and second test of each group gives us a good idea of how two consecutive truckloads of the same coal can vary, according to the evidence of a single test on each. The results we are bringing into comparison are of course subject to instrumental and personal errors in each case, but the fact that they were all taken by one chemist employing the same apparatus gives them a great comparative value.

TABLE VI.

Test No.		Nature of Coal.	Moisture, per cent.	Ash, per cent.	Calorimeter value, B.Th.U.	"As fired" value, B.Th.U.
A	1	Victoria pea slack	3·9	9·58	13,143	12,631
	2	Do.	4·9	10·49	13,043	12,522
	3	Do.	6·75	11·78	12,936	12,063
B	1	Victoria pea slack	3·7	8·18	13,697	13,191
	2	Do.	4·4	12·18	13,002	12,430
	3	Do.	3·75	10·27	13,412	12,909
C	1	½" washed slack	6·60	6·13	13,806	12,895
	2	Do.	7·15	5·66	13,827	12,839
	3	Do.	6·1	5·2	13,868	13,023
D	1	¼" washed slack	7·8	5·89	13,719	12,649
	2	Do.	8·45	5·47	13,729	12,569
	3	Do.	9·4	6·03	13,515	12,245
E	1	1¼" dry Yorkshire slack ...	9·05	12·67	12,264	11,195
	2	Do.	9·85	12·26	12,330	11,116
	3	Do.	15·75	12·99	12,284	10,350

In order to get a numerical idea of the degree of uniformity which may be expected in tests such as those to which we have just referred, we will assume in each case that the average of the "as fired" calorific values of each pair of trucks is the true value of the coal. If we then examine the variations of the individual tests from their respective means we find that the "probable error" of a test is 0·96 per cent. We have already seen that if a number of different chemists analyse the same samples, the probable error of any result is 1·56 per cent. It appears, therefore, that considerably closer agreement will be obtained between tests made by the same chemist on different cars of coal of the same quality, than if the tests were conducted by independent men with possibly different apparatus. This is what might perhaps be expected, but it is nevertheless worthy of note, bearing in mind always that the conclusions have been deduced from only a small number of experiments.

We now come to a different class of test again, and will proceed to consider the consistency between a long series of tests conducted in the same laboratory on the same class of coal. The conditions ensured that variation due to personal and instrumental reasons were a minimum, and the coal in question was from a source which could be depended upon to maintain the quality of the supplies within close commercial limits. The sampling moreover was done with as much care as could possibly be maintained in practice. The incoming coal wagons were dumped into an unloading hopper, and samples collected at frequent intervals from a stream of coal coming through the valve at the bottom of the hopper. About 7 cwt. of coal were collected in this way from every wagon to be tested. Each 7 cwt. sample was coned and quartered down to about 80 lb. in the usual way. This 80 lb. sample was crushed and sampled by a revolving mechanical sampler until a 10 lb. sample was obtained. This was then taken to the laboratory, where it was again mechanically sampled and crushed in a similar machine to give the quantity required for the test. No fairer method is possible, in ordinary power station practice, of getting a sample truly representative of each wagon load, and in the light of these remarks the results obtained must be judged.

The first set of tests to be examined for consistency will be a series of 51, carried out in the ordinary course of business on a washed slack coal during the first eleven months of 1923. As a guide to the nature of the coal we may say that the average value of the constituents, taken over the whole period was as follows: Moisture, 8·56 per cent.; volatiles, 31·23 per cent.; fixed carbon, 59·10 per cent.; and ash, 9·54 per cent. The average calorimeter value was 13,281 B.Th.U. It would be tedious to tabulate the whole of the figures, so that graphic methods may usefully be resorted to in the analysis of the results. Furthermore, it will avoid the vast amount of arithmetic which would otherwise be involved, if the heating values are compared on the basis of the tests on dry coal (calorimeter values) instead of on the basis of "value as fired" which has been used for previous comparisons. The "as fired" value is, of course, as we have already pointed out, the value which should be taken in comparing the cost of fuels, or the efficiency of power stations, or of boiler plants, but our present object is rather to compare variations in the coal itself, and this can equally well be done by eliminating the effect of moisture.

Fig. 1 shows the calorimeter values of the 51 samples arranged in the order in which the samples were taken, and Fig. 2 shows the same tests arranged in order of magnitude. The highest calorimeter value recorded was 13,690 B.Th.U., and the lowest 12,750 B.Th.U., the mean of the whole series being 13,281 B.Th.U., as before stated. Had the variations from the mean been due to experimental errors, it would be reasonable to suppose that they would have followed more or less the "law of normal error," most of the readings being near the mean value and comparatively few being far on either side of this value. Had this been the case, the line shown in Fig. 2 would have been distinctly S-shaped, with a fairly long, nearly horizontal portion in the middle. The sharp downward and upward bends at the ends of the line are in accordance with what might have been expected, but there is practically no sign of the grouping of the values around the mean which the law of normal error demands. The deduction which it appears necessary, therefore, to draw, seems to be that

very considerable variations are to be expected in coal, even when it is of approved commercial uniformity and the sampling and analyses are carried out in a uniform and consistent manner.

The question next arises as to how many samples would have to be analysed before the average of the results could fairly be taken as reasonably representative of the true nature of the coal. The number of samples necesary for this purpose will, of course, depend on the uniformity of the coal, and may be determined by the following simple method. A table of "continued averages" is formed, and continued until the difference between successive numbers in the table is less than what may be considered the unavoidable errors of sampling and analysis. The first figure of the table will be the first analysis, the second figure will be the average of the first and second analyses, the third figure will be the average of the first, second and third analyses and so on. It will be clear that every succeeding analysis will have a less and less influence upon the "continued average," and a time will soon come when the figures in the table will become approximately constant, varying only between very small limits. When the variation has become sufficiently small to be negligible, the final figure of the table may be taken as fairly representative of the average of an indefinite number of samples of the coal under consideration.

If the Fuel Research Board would publish some authoritative statement, backed by evidence which would appeal to practical men, as to the probable error of a random analysis of coal conducted by a competent man, with approved apparatus, they would be doing work of much more real value than much that is now being carried on. Exactitude in coal analysis is not to be obtained, and what engineers want to get is some way of arriving at the true calorific value of the coal they are using, within known limits of probable error. It may be that the average of three random samples of the bulk, taken and tested by different analysts will be near enough, or it may be that a certain number of random samples per hundred tons should be specified, but some standard method of dealing with coal in bulk, more practical than spreading it out on a clean floor and quartering and re-quartering, as recommended by some writers, is urgently needed.

Up to the present we have taken the "probable error" as the measure of the precision of any determination of calorific value, or other feature of the coal, the term having been used in accordance with its mathematical definition. The engineer, however, does not generally think in terms of "probable error." If he makes a statement, such as that a certain distance is one thousand yards plus or minus one foot, he does not mean by this that half the measurements of the distance will make it out to be between 2,999 ft. and 3,001 ft., and half will show it to be outside this range. The meaning he would attach to the statement in question would be that it was practically impossible for the error to be greater than one foot, or in other words, that ninety-nine measurements out of a hundred would agree in giving the length as between 2,999 ft. and 3,000 ft. In short, he thinks of "possible" rather than "probable" error. There is a definite relationship between the mathematicians "probable error" and a "possible error" of any magnitude. If we take the "possible error" to be a variation from the mean which will include ninety-nine out of a hundred observations, and the "probable error" as being that variation which will include 50 per cent. of the observations, the ratio of the former to the latter is as 255 to 67. Thus, the probable error of 1·56 per cent. which we found as characteristic of the determinations of calorific value by different analysts means a possible error of nearly 6 per cent. In other words, if one hundred analysts, with skill and apparatus equal to those who obtained the results of Tables I., II. and III., were to test the same sample of coal, a margin of plus or minus nearly 6 per cent. would have to be allowed in order to include 99 of the results they would obtain. This is the only legitimate deduction from the figures. It may be that the latter are unfortunate examples, but they have been taken from commercial power-station records and were all the comparative figures that could be obtained at the moment of writing. Even if the errors they show are more than might usually be met with, they certainly do much to justify the suspicion with which the thermal efficiencies claimed for some stations are regarded.

Presuming that it is possible, as it should be, to define the calorific value of coal within known limits of probable error, we have next to consider how far this admitted uncertainty will affect the figures of thermal efficiency of the station. The latter figure depends altogether on three measurements, namely, the weight of coal consumed, its calorific value, and the quantity of electricity turned out. The weight of fuel used and the electrical output are both subject to errors of measurement, and there is very little agreement as to how great these errors are likely to be in practice. It is not a question of how accurately coal scales can be adjusted, or electricity meters calibrated, but rather how closely their readings can be depended upon in ordinary working conditions over considerable periods of time.

As an example of the magnitude of the error which is introduced into figures of thermal efficiency of power stations by the individual errors of the factors in the calculation, we will assume that a station is consuming two pounds of coal of a calorific value of 12,000 B.Th.U. for every kilowatt-hour turned out. The efficiency of such a station would, therefore, be 14·2 per cent. Supposing that the probable error in the weight of coal burnt is 2 per cent., and that there is a probable error of equal magnitude in the calorific value, then the heat units used per kilowatt-hour can be expressed as $24{,}000 \pm 537$ B.Th.U., the probable error, therefore, being 2·24 per cent. If we further assume a probable error of 2 per cent. in the readings of the main wattmeters of the station, we get as a result that the thermal efficiency of the station should be expressed as $14{\cdot}2 \pm 0{\cdot}43$, the probable error, therefore, being practically 3 per cent.

THE PROBLEMS OF FRENCH DOCKYARD ADMINISTRATION.

It has been explained in a previous issue that the new French Government has reversed the policy of its predecessors on the question of naval arsenals and intends, shortly, to present a measure to the two Chambers for reorganising the dockyard administration of the country. Up till the present, the Minister of Marine, M. Dumesnil, has given no clue as to the details of the new measure. M. Combescure, Commissaire Principal de la Marine, has, however, recently published an exhaustive study of the problem. Whether the new measure will incorporate the reforms he suggests or not, his views are worth attention, as they are a permanent record of the problems of dockyard organisation.

Richelieu was the first Minister who gave the French dockyards a permanent organisation; but he seems to have hesitated between making them civil or military establishments. His first decree (1631) put a civil servant in charge, and his second placed them under a *chef d'escadre* (1634). Colbert definitely decided in favour of civil control, and, from 1674 to 1765, the French dockyards remained under the control of an *intendant*, a purely civilian officer. The bad equipment of the French fleet during the middle of the eighteenth century and the disasters of the Seven Years' War focused a great deal of criticism on the existing system, and a decree of 1766 installed two authorities, instead of one, in the royal dockyards. The *commandant du port* was in charge of all technical and military questions; the *intendant* was responsible for administration. Buonaparte restored the former unity of command, and laid the foundations of the present system. By a decree dated "7th floréal, au VIII," a *préfet maritime* was placed in charge of every dockyard, and under him were the chiefs of the military, administrative, and shipbuilding departments. Except in a brief interval during the Restoration, the *préfets maritimes* have remained the officers responsible for the proper working of French dockyards. The subsequent history of the dockyards has altered their inner organisation, but left the principle of placing them under the sole authority of a naval officer untouched. Two tentative alterations carried out in 1828 and 1835 led to the *ordonnance* of 1844, which M. Combescure describes as the "constitutional charter of the French yards." By this decree the *préfet maritime* had under his orders: (1) the major-general, responsible for the troops in the arsenal; (ii) the director of naval construction; (iii) the director of port movements; (iv) the director of artillery; (v) the director of hydraulic machinery; and (vi) a public health officer. The departments of these officers were, however, all subject to supervision by the *commissariat général de la marine*, or, as we should call it, the accountant-general's branch, which acted as an intermediary between the technical branches and the civil contractors, controlled the employment of labour, and was in charge of all dockyard finance.

From 1844 onwards all decrees have increased the independence of the technical branches, and reduced the control originally exercised by the *commissariat général*. A decree of 1900 practically brought it to an end, and instituted what has since been termed "departmental autonomy." Each dockyard branch now obtains its own material, and deals with its labour problems independently, subject, of course, to such Treasury control as is necessary to ensure that no department exceeds its vote.

The history of French dockyard organisation thus shows that the arsenals have been administered on three distinct governing principles—single control, double control, and single control with autonomous technical branches. The system which gave such wide powers of control to the *commissariat général* was doubtless one which worked economically, but it cannot be restored with any hope of success. If it proved too rigid for the old sailing navy, which was the charge levelled against it, it would be doubly so to-day, when the technical and scientific sides of dockyard administration have increased so much in complexity and importance. Nor will it be possible to "industrialise" the dockyards as has been suggested. A naval arsenal exists for a military purpose, and it cannot be administered like a shipbuilding yard, which exists only for commercial transactions. The methods by which modern industries divide labour, and specialise duties, may none the less be copied with advantage.

It has also been suggested that the dockyards should be divided into two branches—the one concerned with the fully-equipped fleet; the other with all ships under construction and repairs—and that each should be under the control of an independent chief. The first would have under his orders the provisioning, personnel, public health, and military branches; the second would be in charge of the branches concerned with naval construction, artillery, and hydraulic machinery. This solution is likewise impossible; the departments could not be thus divided, as several of them are as essential to the fully equipped fleet as they are to the ships under construction. It is none the less an idea which might be made the basis of a sound financial reform; for costs and charges might with advantage be divided into two general headings—one recording the expenses of maintaining the fleet as a military unit; the other setting out those incurred under new construction and repairs.

The real trouble from which French dockyard administration is suffering arises from two sources—(i) departmental autonomy, and (ii) a lack of co-ordination between the technical and administrative services of the arsenals, and the central naval authority in Paris. The independence given to the various branches of the dockyards by the decree of 1900 was doubtless necessary, but it produced reduplication of work. Each branch, striving to make itself as self-contained as possible, undertook a certain amount of work which others were doing at the same time. The only cure will be to make an exhaustive survey of all the workshops, engine sheds, store houses, and offices at present in existence, and to re-group them into administrative units, on the model of great modern industries. The second trouble can be more easily

put right; the remedy will consist in giving each technical and administrative department in the naval arsenals a corresponding department in the rue Royale. A great step has already been taken in this direction by organising the staffs of the *préfets maritimes* upon the model of the naval general staff at headquarters. On the question of command, Monsieur Combescure is decisive: a dockyard exists solely for a military purpose. There can, therefore, be no thought of returning to the civil administration which Colbert favoured. The person responsible for working and maintaining a naval dockyard can only be a naval officer of flag rank, and he cannot divide his authority, or delegate any part of it to others.

HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

(*Continued from page* 97.)

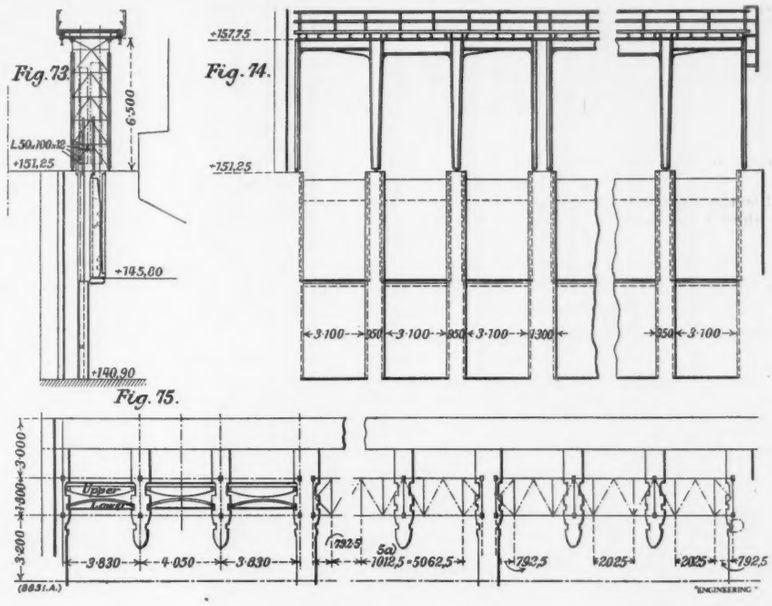
THE gates for closing the intakes to the turbines are divided, so that the total depth is covered by two gates one above the other. As already explained, each intake is divided by vertical partition walls into three. The actual opening between these walls at the sluices is 3·1 m. (10 ft. 2 in.). The arrangement will be followed on reference to Figs. 73 to 75, the plan, Fig. 75, showing the side walls, the main piers separating the three intakes, as well as the intermediate partitions dividing each intake into three. The arrangement of the double gates is shown in Figs. 73 and 74, the former—a side elevation—shows the manner in which the upper gate is stepped back so as to allow the lower one to be raised. The plan, Fig. 75, shows also, on the left, the double gates in their recesses between the piers. The division of the sluice gates into two in this way, has been due to a desire to reduce the individual weights to be handled by the hoisting machinery, and also the weight and the height of the overhead gantry from which they are handled. Leaving for the moment further reference to the latter, we will proceed to describe the cambered sluice gates themselves. These we illustrate in Figs. 79 to 91, page 156. The upper gates are illustrated by Figs. 79 to 82, and the lower by Figs. 84 to 86. Fig. 83 shows the relative position of the two gates when in the recesses. This particular arrangement has made possible the use of guides of shallow depth, by reason of which the thickness of the walls has been reduced.

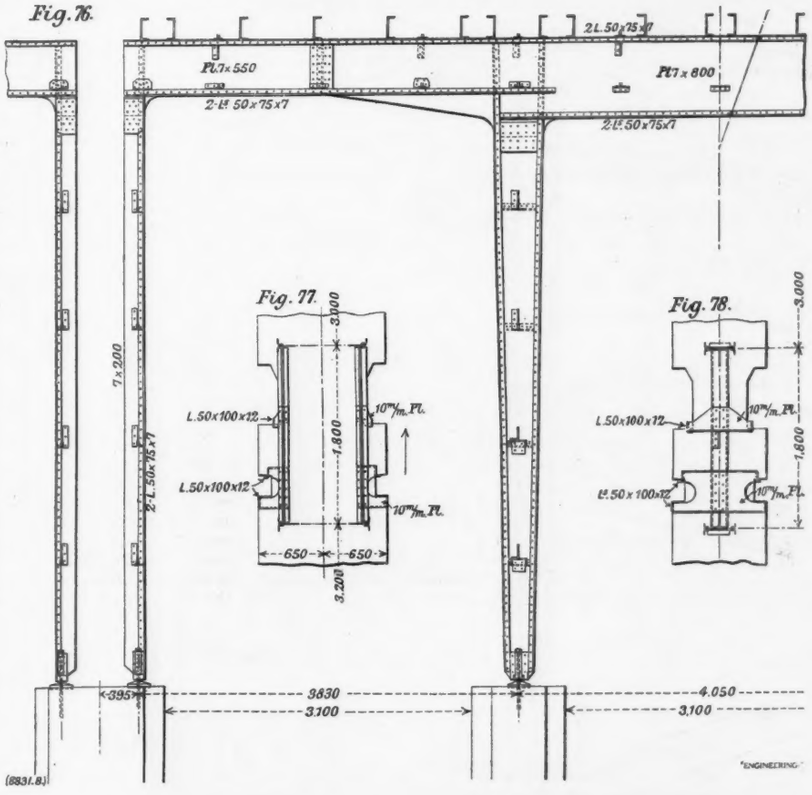
Both the upper and lower gates are built up of stiff side members connected by strong bellied cross girders, constructed of double angles and pierced plate. The camber is struck with 5 m. (16 ft. 5 in.) radius for the upper gates, and 4 m. (13 ft. 2 in.) for the lower. The plating in both cases is on the curved face. In the upper gates the convex side takes the water pressure. In the lower gates the concave side faces up stream. In both cases the plating is 7 mm. (0·28 in.) thick. The depth of the gates from back to front is 450 mm. (17·7 in.) for the lower, and 530 mm. (20·9 in.) for the upper. The height of the gates is 4,800 mm. (15 ft. 9 in.) for the lower one, and 5,000 mm. (16 ft. 5 in.) in the case of the upper, the depth of the recesses being 130 mm. (5 in.) and 200 mm. respectively. The upper gates, illustrated in the view, Fig. 92, page 157, have only two main cross girders, as will be clear from Figs. 79 and 80. The loads from these are transferred directly to two pairs of wheels on each side of the gate in fixed bearings. For the rest the gate plating is stiffened by small cambered channels. The load on the wheels is comparatively small and it was thus possible to reduce the spans and the depth of the guides. The span between the rollers, across the gates, is 3,250 mm. (10 ft. 8 in.).

The lower gates, illustrated in Figs. 84 to 86, have eleven cross girders which distribute the load evenly along the guides. The span of the gates was somewhat reduced and it was found sufficient to use comparatively light flat iron bars for the guides. Two small guide rollers are fitted to each of the upper and lower gates.

Details of the recesses and seals are given in Figs. 87 to 91, on page 156. Fig. 87 shows the recesses for both the upper and lower gates. The lower gates as explained are forced by the water pressure against plain iron strips anchored into the concrete. These gates are guided by small rollers running on angle irons on the up stream corners of the recesses. The wheels taking the load of the upper gates run as shown on vertical flat bottomed rails. The guide rollers in this case are arranged on brackets and work inside the recesses. The side seals for these gates are made with hollow steel rods suspended as shown in Figs. 89 and 90 from brackets fixed to the gates and moving with them. The rods are spring supported, at the upper end and forced by the water pressure up against bronze fitting strips on the recess sides. Fig. 88 shows the gate ends, guides, &c., in elevation. Each gate opening is divided horizontally into two by a cross beam on which the upper gate rests. The seal between the gate and the beam is made by canvass and hemp rope packing gripped between strips of wood, and let into a groove. The seal at the foot of the bottom gates is formed in like manner, while at the top packing is also provided, fitting at the back of the gate into a wedge-shaped slot between the gate and the cross beam as shown in Fig. 91. This cross-beam is seen in Fig. 84 and its position with regard to the two gates, in Fig. 73.

The latter figure, with those up to Fig. 78, relate





HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

Fig.79. UPPER GATE

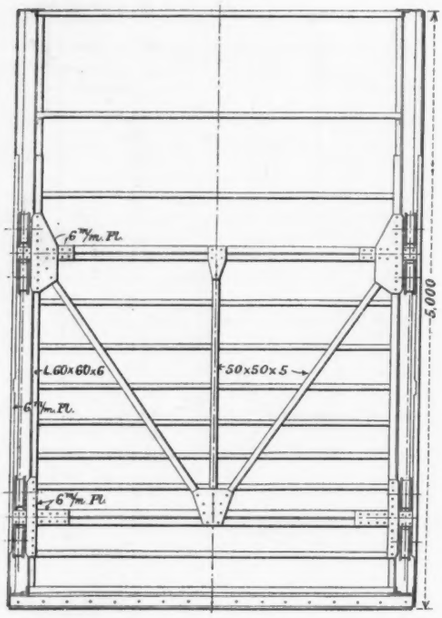


Fig.80.

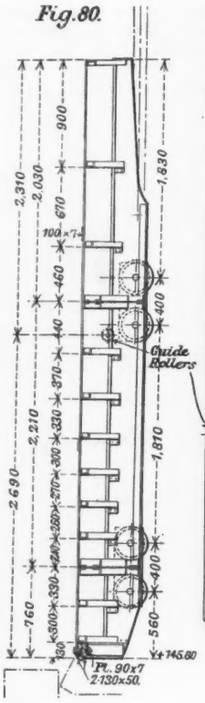


Fig.84.

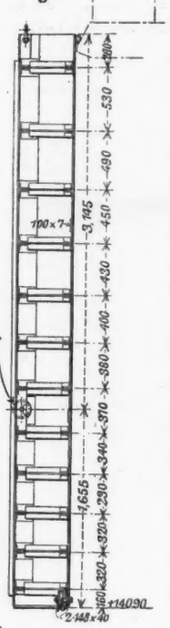


Fig.85. LOWER GATE

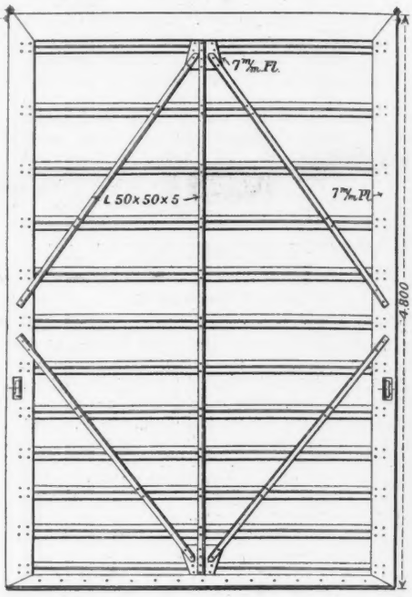


Fig.81.

Fig.82.

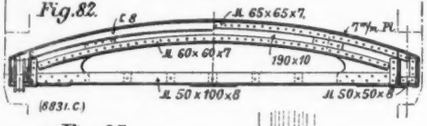


Fig.83.

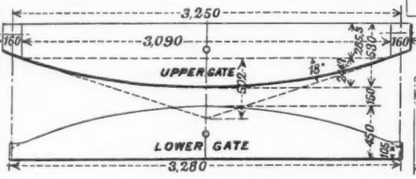


Fig.86

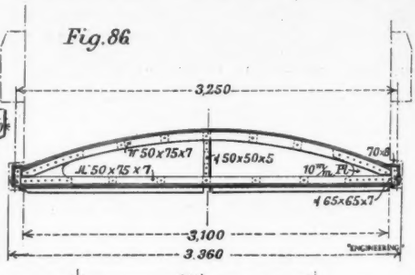


Fig.87.

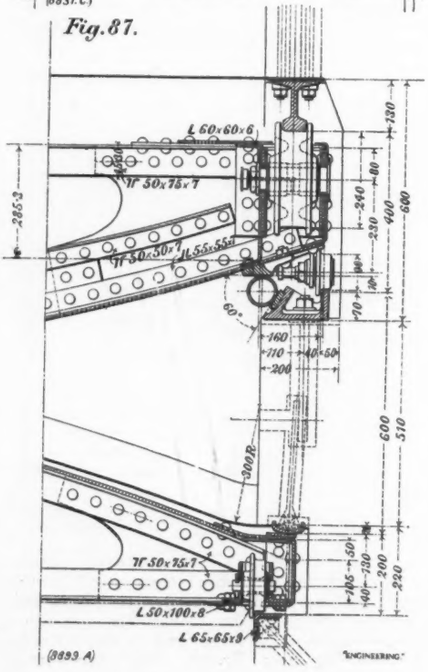


Fig.88.

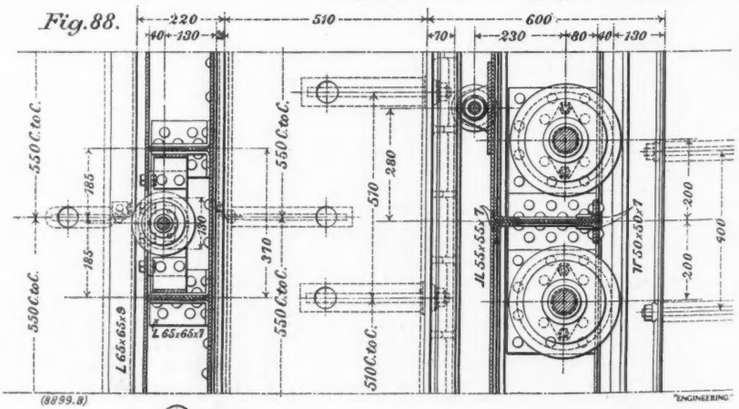


Fig.89.

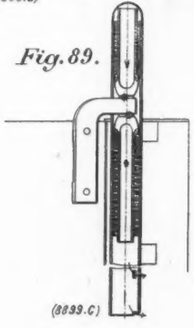


Fig.90.

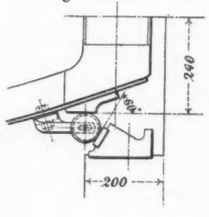
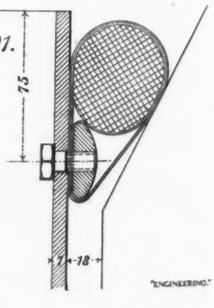


Fig.91.



HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

FIG. 92. UPPER SLUICE GATE.

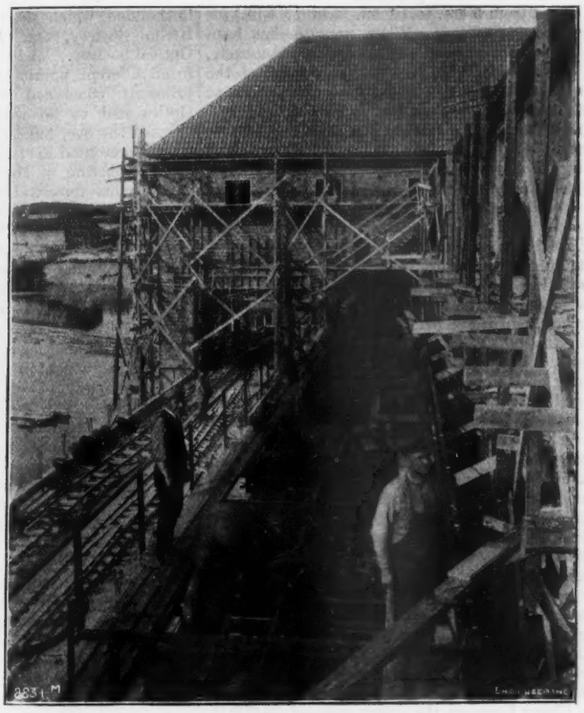
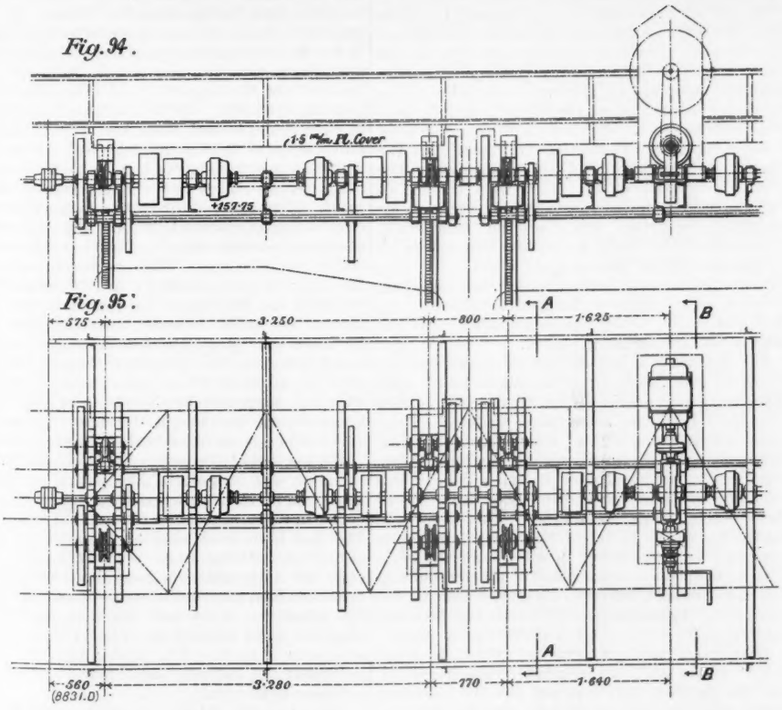
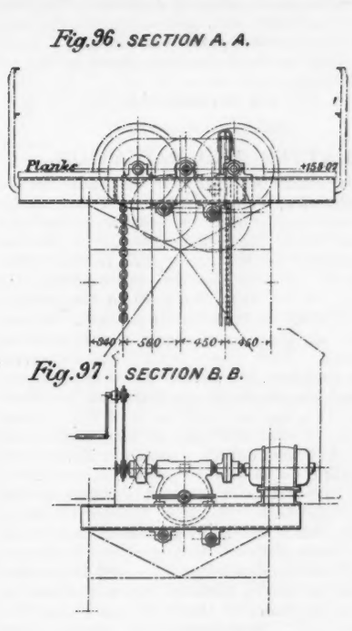


FIG. 93. GATE OPERATING GEAR.





to the overhead gantry structure used in connection with the operation of the gates. The whole gantry consists of three structural units each supported on eight legs resting upon the party and side walls of the intake. Fig. 73 shows the gantry in end elevation. Fig. 74 shows, on the left, a complete unit and on the right, parts of the other two, which are similar to the complete one shown. The plan, Fig. 75, shows the positions of the feet of the legs on the walls. Fig. 76 shows to a larger scale, parts of two adjacent units. Each structure is symmetrical about the middle of the length, the centre line of one unit being shown towards the right hand of Fig. 76. Fig. 77 is a plan at a main pier, showing adjacent ends of two units of the gantry, while Fig. 78 is a plan of one of the smaller intermediate piers or party walls, on which a single pair of legs rest. The structures are built up of plates and angles, the former having a ruling thickness of 7 mm. (0·28 in.), while the angles are for the most part double and of 50 mm. by 75 mm. by 7 mm. (1·97 in. by 2·95 in. by 0·28 in.) section. The two main longitudinal girders are cross-connected, both with bracing in horizontal planes and diagonal bracing arranged in vertical planes to stiffen the whole to withstand wind pressure and other strains. Extending across the gantry are placed a number

of channels about 3,100 mm. (10 ft. 2 in.) in length, and on these is fixed the hoisting machinery with a platform of 2½-in. planking. Railings extend along either side. In operation, the upper gate is first raised from 5 cm. to 10 cm. (2 in. to 4 in.) for the purpose of filling. When pressure has been equalised, the two gates are raised simultaneously, but the lower is lifted at twice the speed of the upper, so that the two reach their highest positions at the same time.

The hoisting gear is illustrated in Figs. 93 to 97, page 157, Fig. 93 being a view looking along the top of the gantry. One motor only is used to work all the gates, a single shaft, driven by worm and worm gear, running along the whole length of the gantry. Expansion couplings are provided between the gantry units. The arrangement of the motor is shown in Figs. 94, 95 and 97. In the event of failure of the motor, the shaft may be turned by hand, by the crank and chain best seen in Fig. 97. The lower gates are raised by means of chains running simply over chain pulleys. The upper gates are raised and lowered by rack and pinion drive. The various gears are engaged with the driving shaft by means of friction clutches. Below the channel cross bearers will be seen in the drawings, Figs. 96 and 97, two longitudinal shafts. These are driven from the main shaft on engagement of the proper clutches. The arrangement may be followed in Figs. 94 and 95, where it will be seen that the clutch and gears driving the near shaft are placed near the left-hand chains of a gate, while the gear for the back shaft is more to the right. The friction clutches will be clearly seen in Figs. 94 and 95. The gates are lowered without the use of the motor, the operation being controlled by means of centrifugal brakes which are indicated in these illustrations between the clutches and the actual hoisting gears, on hollow shafts. The gear ratios adopted give a maximum lifting force on the upper gates of 18,000 lb. and for the lower gates of 9,000 lb. The motor can also be employed to exert a maximum downward force on the upper gates, of 4,500 lb. The total weight of a gantry unit, gear and gates, for each group of three sets of gates, works out at 37 tons. The movable parts of the gates figure in this for about 18 tons.

(To be continued.)

MATTER AND RADIATION.

In his presidential address to the Radio Society on Wednesday, January 21, Sir Oliver Lodge said that his interest in wireless waves went back to Clark Maxwell, whose great treatise was published in 1873. In 1875 he had spent the whole of the summer in studying the theory of electric waves set forth in this volume, which excited his enthusiastic interest. It was, however, at that time purely a mathematical speculation. They knew neither how to excite, nor how to detect, the waves. Later on, however, Hertz and himself almost simultaneously succeeded in doing this, but the experiments of Hertz established the actual existence of the waves more satisfactorily than did his. Later on, Marconi put the matter of wireless wave production and detection on a substantial financial, commercial and governmental basis. Still later Fleming introduced the valve, and it was really astonishing what could now be accomplished. In those days it was not thought that wireless telephony would be possible, nor that the waves would go any way round the earth, but he was told that amateurs to-day were able to "get" New Zealand by utilising short waves.

All conductors were full of loose electrons and a copper wire might be regarded as an elongated crowd of loose electrons. When we wished to reflect a wave we used for the purpose a good conducting sheet. Eccles and Heaviside had shown that similar crowds of loose electrons were produced in the upper atmosphere under the influence of the sun. It was this crowd of loose electrons which reflected the wireless waves and thus made it possible for them to travel nearly round the earth. The existence of this reflecting layer must be regarded as an astonishing piece of good luck, which could not have been anticipated. It directed the wireless waves round the earth instead of letting them pass off into space.

There were, Sir Oliver continued, three societies in London which dealt with radiation, viz., the Radio Society, the Röntgen Society and the Optical Society. The three approached the subject from different points of view, but all three were primarily concerned with waves in the ether. Optics had to do with the special kind which affected the eye, but the whole of the waves which were represented in spectra might be included in it. The deciphering of these complicated line spectra was a most remarkable fact. To the uninitiated the lines suggested nothing but confusion, much as did the grouping of the stars seen on a winter's night. In both regions, however, law and order had been found to reign. The universe, must, in the ultimate, be intelligible, no matter how hopelessly confused it at times appeared.

The study of the spectrum went back to Newton, but two of the societies, he had mentioned were newcomers, which in the Twentieth Century took over the study of phenomena discovered in the Nineteenth. Both societies dealt with ether impulses—one with the biggest waves yet used by humanity and the other with ether pulses of extreme minuteness, smaller than the atoms themselves. The simplicity of the ether, however, was such that all waves, whatever their size, travelled through it at the same rate. To detect the smallest, phosphorescent effects were relied on or use was made of photographic plates. In the detection of the waves of intermediate length, the eye sufficed, whilst to detect the long waves we had to employ some form of rectifier, either crystal or valve, and then by the aid of that remarkable invention the telephone, the pulses in the ether were finally converted into sound. We knew little about how luminous waves were detected. The action of the retina was familiar, but no satisfactory explanation of it had yet been arrived at, and there was still a controversy on the subject of colour vision.

We did not even know how to generate luminous waves directly. All we could do was to stimulate an atom by heat, or by chemical action, and trust to the atom to give us light. X-rays were produced by suddenly stopping an electron, and radio waves by taking advantage of the electro-magnetic properties of the ether. Wireless oscillations depended in short, upon two characteristic properties of the ether; its elasticity and its momentum. The electric properties of the ether were responsible for its recovery from electric strain, whilst to its magnetic properties was due the momentum, which caused the charge to overrun the position of equilibrium and to pile up again a state of electric strain. Neither this method nor the stopping of an electron could, however, be used to generate the luminous waves, which were too small for the one method and too big for the other.

The discovery of the electron, and the working out of some of the details of atomic structure, had, however, thrown a good deal of light on the question as to how luminous waves were produced. Each atom constituted a sort of solar system in which electrons revolved round a central nucleus. Only some orbits, however, were stable, and light was radiated only when an electron leapt from one of these stable orbits to another. This view was chiefly due to the genius of Bohr, but it had been confirmed in astonishing detail by an elaborate analysis of spectra, as one result of which chemistry was now invaded by physics. By these researches our views as to the constitution of matter had been not only enlarged, but in some respects revolutionised.

Matter and radiation being his subject, he could not, Sir Oliver said, help referring to these questions, but the Radio Society was not directly concerned either with the nature of radiation or with the details of atomic structure, even although it made great use of electrons. The radio-engineer dealt not, however, with single electrons, but with crowds. His instruments were of sensible size, and responded to surges of these crowds against the barrier presented by the end of the aerial. From this they were thrown back by the elasticity of the ether, the electrons thus surging backwards and forwards like a panic-stricken crowd.

In general, oscillations were always due to a combination of elasticity and inertia. It was not quite known whether the electrons in a conductor were entirely loose, or whether they were passed on from atom to atom, as a fire-bucket might be passed from hand to hand. For all practical ends they might be considered as loose, but the matter had not yet been worked out. Certainly they were not completely loose from the atoms, since they jostled and shook these as they surged past them, with the result that the conductor got hot, the energy of the moving electrons being rubbed down into heat. This, however, was not an inevitable consequence of the movement of the electrons, since near the absolute zero of temperature the atoms became still and quiet, being, as it were, frozen into fixed positions. The electrons, however, were not frozen, but they no longer jostled the atoms so that a current once started in the conductor went on indefinitely. For all practical purposes, however, Ohm's law represented the facts.

How did we generate radiation, and what was it? It was purely a tremor in the ether. A tuning fork could produce waves in air, but not in ether, since there was no mechanical connection between the two. This had, Sir Oliver proceeded, been tested by himself at Liverpool many years ago, when he had spun a steel disc nearly up to the bursting point in the hope of finding evidence of some connection between this mechanical motion and the ether. Matter proved, however, to have no handle for ether, which, in spite of its density (and, he held this to be millions of times greater than that of platinum), was devoid of viscosity. There was, in fact, no necessary connection between density and viscosity, which was what made it so very difficult to experiment on the ether. It was this absence of viscosity, moreover, which made it possible for the earth to spin for ever. The connection between matter and ether was electrical, not mechanical. A charge might be concentrated on an electrode, but the field extended into the ether. When the charge moved, lines of magnetic force were generated which were all closed rings surrounding the paths pursued by the electrons. It was these magnetic lines of force which conferred momentum on the moving charges. Neither the electric field nor the magnetic field taken alone could generate radiation. We had to have the two fields at right angles to each other, and we could then get an emission of light at right angles to both fields. This was one outcome of Clerk Maxwell's theory.

An electric charge was wholly composed of electrons. If we changed the speed of a moving charge, electro-magnetic waves burst out. Radiation was, in short, produced by changing the speed of an electron and in no other way. This conclusion was due to Larmor, who had published it in 1900, and had thus provided the foundation for the views now held. Larmor concluded, however, that radiation might be given out by an electron moving at constant speed in a circle, but Sir Oliver thought that there must in all cases be an actual change of speed. This was suggested by Bohr's theory of atomic structure, and he thought therefore, that Larmor's views should be modified in this direction.

We knew that the action between electrons and radiation was reciprocal. The jerk of an electron generated an electro-magnetic wave, and this wave could, in its turn, start an electron out of an atom. This had been established by the study of photo-electricity. Atoms when properly jostled, might emit not only radiation, but also electrons. All metals, in fact, gave out electrons if suitably jostled by radiation. Gold and silver would not lose electrons when exposed to ordinary light, but did so under X-rays. The lighter metals, such as potassium and sodium, did, however, respond to ordinary light rays.

There was, Sir Oliver continued, some substance in the retina which threw away electrons with characteristic speed when acted on by light. Vision was due to this. He doubted if electric tremors affected the nerves directly. The eye apparently contained three different substances, each of which responded to a different frequency. These three gave us the three sensations of red, green and violet, out of which all our colour impressions were compounded. He believed that what stimulated the nerve was

the throwing off of an electron with considerable violence. This action did not depend on the intensity of the light. There was always some response even with the feeblest lights. It was this characteristic which made the eye so sensitive. What the nerve felt was the shock due to an electron moving at a speed of some thousands of miles a second.

The eye was the first wireless instrument used by man, and vision was a photo-electric phenomenon. Vegetables also exhibited photo-electric properties, but with them we got not vision but chemical action resulting in a molecular rearrangement. We interpreted the impressions made on the retina just as we did the scattered spots which made up a process block. This interpretation was ours, but the formation of the images depended upon an optical instrument, the lens. Vegetation had no optical apparatus, but had substances which responded to light. As a consequence we had the formation of vegetable tissue and the phenomenon of growth. He had himself made some observations, hitherto unpublished, on the electrical properties of living leaves. When insulated he found that they became charged.

Thermionic emission formed another branch of the subject. The study originated with Guthrie, and the phenomenon had been applied by Fleming to the electric valves, which had now almost become a domestic instrument. In thermionic emission the electrons did not emerge with a characteristic velocity, and the phenomenon might be regarded as a kind of electric evaporation. In the valve the film was kept hot to enable the electrons to evaporate, but the anode was not heated. The valve let the electrons pass in one direction only, and it thus made it possible to accumulate electricity of one sign. Some crystals, for reasons best known to themselves, were able to act similarly. In this way we could convert the extremely rapid etheric oscillations into the moderately rapid ones which actuated the telephone. The grid, introduced between the cathode and the anode, acted as a regulator of the electron traffic, compelling the procession to follow every fluctuation due to the consonants and vowels of human speech. The main marvel was not, however, that the electrons could be thus controlled, but that an iron plate could reproduce speech. All the plate could do was to vibrate as it was compelled. There were, however, a few sounds it did not like, for example, it discriminated badly between *f* and *s*. No analysis of the vibrations was attempted by the instruments used, and all speech existed for a time in an inorganic unconscious form as the quivers of an iron plate, or as condensations and rarefactions in the air. The analysis of these was effected in the ear. How was it that we got from this confusion of movements to the ideas of a Shakespeare or a Beethoven? All he could say was, that one mind somehow stimulated another, and we were mechanically put into connection with these greater minds. The ordinary process to which we had grown accustomed contained very much that was astonishing. Some day other means of intercommunication from mind to mind might seem simpler and more natural.

Electric positive and negative charges tended to neutralise each other's effects. This was why matter appeared neutral. When the charges approached each other we had radiation. Did they ever actually combine? We did not know that this occurred on the earth where, in fact, something seemed to keep them apart. The operation was, however, a conceivable one. Some of the stars, moreover, had temperatures of millions of degrees, and strange and violent things might be going on within them, and perhaps some day we might even in the laboratory get an actual combination of two opposite charges which would then vanish in a puff of radiation. All that would then persist would be the energy of this, travelling across space at the speed of light. The charges would themselves have become part of the ether. Astronomers were beginning to think it probable that this process was actually going on in the stars, which were in certain cases blown out like a football by the intensity of the radiation within them. The pressure of "highly condensed" light might, in fact, be enormous, although on the earth the pressure of radiation was barely measurable. Any phenomenon however, which occurred, on no matter how small a scale, here, might become very important elsewhere.

Some such hypotheses as the mutual annihilation of positive and negative charges seemed necessary to account for the continuance of stellar radiation for billions of years. But if matter were thus disappearing, the energy still persisted, though no longer associated with matter. The doctrine of the conservation of matter, indeed, showed signs of going by the board, and matter was now being regarded as a form of energy. In the past the two were thought to be distinct, but nowadays there was a great tendency towards this unification. If matter were made up of positive and negative units, as experiment seemed to show, and if these ever actually clashed together, then the matter would be destroyed.

He looked forward, Sir Oliver proceeded, to the establishment of the view that matter was ether in motion, so that what was matter at one moment might be radiation at another. Jeans told us that the sun was maintaining its radiation at the expense of its own substance, just as if it were a mass of burning coal. When coal burned, however, the matter was not lost, but turned into gas, whereas in the sun, matter was being actually destroyed (according to Jeans' calculation) at the rate of 4 million tons per second. Of this we received on the earth the equivalent of 2½ cwt. per minute. Four million tons a second seemed a lot, but the sun could maintain this for a million centuries without apparent change, though in time it must, of course, exhaust itself. Was there, he proceeded, any reciprocity? Could radiation turn into matter? We did not know, but he suspected that we should ultimately find that it could, and that in the confines of space matter was being generated from radiation, and that there was no ultimate dissipation in the universe.

The electron was, he thought, composed of ether somewhat as a knot was composed of string. He believed that in the long run all physical phenomena would be explained in terms, first of electricity and then in terms of ether in vortical motion. Fitzgerald and Kelvin had attempted to do this.

For his own part he believed that the ether was under the enormous pressure of 10^{33} tons per square centimetre, and that it was this pressure which held the electron together in spite of the self-repulsion of its parts. A soap bubble charged with electricity expanded, and if in an electron the electricity was all of the same sign why did it not do the same? He would suggest that it was because of an etheric pressure equivalent to the air pressure, which limited the expansion of an electrified soap bubble. Regarding the electron from this point of view, he had been able to calculate that its diameter would be 10^{-13} cm., which was in agreement with experiment, and with this as basis the pressure needed to prevent its expansion came out, as stated, at 10^{33} tons per square centimetre. On this view the electron was a hole in the ether. What had become of the "inside"? Well, the proton had the same charge (numerically) as the electron, but 1,845 times as much mass, and he made the guess that the "inside" of the electron had been jammed inside the proton, and with this condition of affairs the electron was not happy and wanted to get it back, from which resulted the mutual attraction. The ratio 1,845 was, he continued, a very important and mysterious number, of which the significance was not yet understood.

Speculation was inevitable in modern physics, but it should be understood that it was never random speculation, but was always suggested by experiment and observation. The Newtonian framework had proved most useful, but gave us no details, and when we dealt with the infinitely small, dynamics began to fail us, and matter to resolve itself into discontinuities which were unintelligible without the hypothesis of an ether.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, announces that tenders are invited until March 1, 1925, by the Municipality of Montevideo (Uruguay) in connection with drainage works to be carried out in the district of Paso Molino. The total estimated expenditure is 400,000*l*. Some particulars relating to these works are available at the Department.

ASSOCIATE FELLOWSHIP OF THE ROYAL AERONAUTICAL SOCIETY.

SOME uncertainty having arisen as to the qualifications required from persons desirous of becoming associate fellows of the Royal Aeronautical Society, the council have deemed it advisable to issue a statement as to their interpretation of the regulations relating to membership in this grade. Election to associate fellowship is confined by the regulations, firstly, to those who pass the Society's own examination or possess an equivalent university or technical college qualification followed by two years' practical experience in the application of the science of aeronautics; secondly, to those who present a thesis; and thirdly, to those who have exceptional qualifications or achievements to their credit, but lack the examination qualifications called for in the first-mentioned regulation.

It has been suggested that these regulations might debar from associate fellowship such men as section leaders and senior draughtsmen, who would be quite capable of designing a complete machine, if required to do so, and who are regularly responsible for detail design as well as for preliminary designs and performance calculations. Men of the type referred to, having left college for perhaps 15 or 20 years, would be likely to find an examination a much more formidable obstacle than it would be to a younger and less experienced man. The council, however, explain with regard to the first of the above-mentioned regulations that they accept the degree or diploma of any recognised university or technical college at home or abroad and excuse from the aerodynamics paper of the Society's own examination, the holders of diplomas in aeronautics of such universities or colleges. For the thesis referred to in the regulations, they do not insist upon the presentation of a record of some original work, what is required being a communication of such a character that an adequate idea can be obtained of the candidate's knowledge and experience in aeronautics or in an allied subject applied to aeronautics.

Among persons possessing exceptional qualifications the Council have accepted airship pilots, and aeroplane test and experimental pilots whose work has been, or is considered likely to be, of value to the technical development of aeronautics, and they have also accepted workers of such long standing that they may be regarded as pioneers. The Council, we understand, are likely favourably to consider applications from persons of the type above referred to, each application unaccompanied by examination qualifications or by a thesis being considered on its own particular merits. Their aim, however, is to raise associate fellowship of the Society to the same level as that of other institutions and considerable technical qualifications and/or experience are therefore regarded as essential to membership in that grade.

THE REPAIR OF LA VOULTE CAST-IRON RAILWAY VIADUCT.

IN a former issue (see ENGINEERING, vol. cxviii, page 557) we gave a brief account of the reinforcement of La Voulte railway viaduct over the Rhine, originally built in 1861. The location of the viaduct is shown in the plan, Fig. 1 on page 160. The viaduct has one track only, and is of five spans of 55·60 m. (182 ft.) each, carried on four masonry piers. The original structure was of cast iron, each span consisting of four arched ribs strongly braced together. Transversely, the bracing was built up of rectangular cast-iron frames, stiffened at certain places by diagonals forming part of the castings. In a direction parallel with the axis of curvature the connection of the arched ribs consisted, above the intrados, of horizontal cast stays, and, below the extrados, of horizontal double frames of cast-iron stiffened at the four corners by cross pieces, also connected to the arched ribs. Moreover, at top, and in a horizontal plane, the two intermediate arched ribs or the spandrel frames were connected by cast-iron transverse members carrying jack-arches, on which rested the track with the interposition of a layer of ballast. The two intermediate arched ribs or

spandrel frames, were connected to the adjacent outside arched ribs by transverse castings carrying jack-arches underneath the footways.

The viaduct in time developed numerous defects, notably in the main ribs and in the bracing of the ribs and spandrels. The design of the viaduct, the defects which had developed and the methods adopted in making these good, are illustrated in Figs. 2 to 28 on Plates VIII to X and on page 161. Cracks had formed and appeared to have been due to two main causes. The first of these was excessive stiffness at the joints. The cast-iron dovetailed bracing fitted into recesses cast in the voussoirs sections, and in which they were held by keys and iron cement. All the component parts were very massive and rigid in themselves and at their joints, and heavy stresses caused by the traffic, or due to uneven expansion with changes of temperature, were bound ultimately to cause fractures. The bracing castings gave way, as shown in Fig. 20, Plate X; fractures also occurred in the recesses or at other parts as can be seen in Figs. 21. In the second place, fractures were traced to the iron cement; this in course of time and at the parts specially exposed to dampness, became oxidised, and by swelling led to the formation of cracks in the dovetail recesses and, at other places, also in the flanges. Cracks had also occurred in other members and the bracing had been seriously weakened.

In 1910, provisional strengthening work was carried out. This consisted in the fitting of wind bracing between the four arched ribs, as shown in Figs. 4, 5 and 9. It was possible to add this bracing to the two intermediate arched ribs by taking advantage of holes cast in them; no fresh holes were drilled, except at the first courses of the voussoir sections next to the skewbacks. This bracing effectively relieved the damaged cast-iron framework and ensured the transverse stability of the viaduct. This was most desirable in the case of arches of 55·60 m. (182 ft.) span and subject mostly to compression stresses. This strengthening, however, was soon found to be insufficient, and traffic over the viaduct had to be restricted to light train loads only.

In 1913, owing to the relatively low price of steel, it was decided to replace the viaduct by a new one, and the designs were got out for a steel platform on continuous, straight girders. The order for this was even given, and a certain amount of steel work had already been prepared when the war supervened and put a stop to the scheme. The matter was reconsidered in 1920, but at that date the price of steel had reached such a high figure that a cheaper alternative had to be decided upon, and it was finally resolved to strengthen the existing structure still further. The investigation of the best method to adopt went into every detail and occupied twelve months; when it was completed, work was started at the site. Fig. 9 shows the alterations effected.

The programme comprised the following work:—(*a*) The replacement of the cast-iron bracing rigidly fixed to the arched ribs by steel frames connected to them by bolts. (*b*) The strengthening of the weak parts of the arched ribs, especially along the lower chord, where serious damage was found to have occurred. (*c*) The connection of the arched ribs together both along the intrados and level with the roadway. (*d*) Modifications to insure the accurate distribution of the live loads over the four arched ribs (two intermediate and two outside ones). (*e*) Bracing to transfer to the voussoirs sections near the springings the transverse stresses exerted at the track level. (*f*) As a subsidiary, but most useful feature, to facilitate access for inspection. Each of these sections of the work is considered in detail below.

The cast iron bracing connecting the arched ribs were badly damaged, as can be seen from the views, Figs. 20 and 21. Steel frames built up of plates and angles were first fitted in a line with all the voussoir joints, as shown in Figs. 10, 11 and 12. No holes were drilled in the arched members; the frames were fixed by bolts, and the bolt holes connecting the voussoir castings together were utilised for this purpose. When a steel frame was fitted in place, the corresponding cast-iron bracing was removed. The removal of the bracing in every instance was accompanied by difficulties and had to be carried out with great care, mainly by reason of the iron cement holding the bracing in the dovetail recesses cast in the voussoirs. The cement, which probably contained cast-iron filings, could not be removed by the oxy-acetylene blowpipe and could not be chipped off. The pieces had to be cut out close up to the recesses by drilling with an electrically-driven drill, the "tenon" remaining in the recess being then cut through vertically by the same means. The two halves of the "tenon" were then forced together for removal from the recess, which was then cleaned out.

The strengthening of the lower flanges of the arched members was effected by means of two steel round bars, 36 mm. (1·4 in.) in diameter, placed one on each side and level with the lower flange of the voussoir castings (Fig. 16, etc.). These bars were connected to the voussoirs by steel brackets fixed to the arched ribs 2 m. (6 ft. 6 in.) apart, by 20 mm. ($\frac{3}{4}$ in.) bolts, one bolt for each bracket. The two round bars which are continuous over the whole length of the arched ribs suffice for strengthening the flanges at the parts which were in a comparatively good state of preservation. One or two supplementary round bars of the same diameter have been placed at all damaged portions of the flanges. These supplementary round bars are fixed to the same brackets as the continuous bars and extend beyond the damaged portions for a length of 2 m. (6 ft. 6 in.) on either side. Independently of their fixing to the brackets carried by the lower flange, the 36 mm. round steel bars are connected together every 20 cm. (7·8 in.) by 12 mm. ($\frac{1}{2}$ in.) steel rods which run through the web of the voussoir sections, and surround the 36 mm. bars, as shown in Figs. 11, 15, 16 and 28. The 12 mm. rods are held in the web of the voussoirs by steel wedges driven in tight; for this purpose the holes drilled in the web of the voussoirs are 15 mm. ($\frac{5}{8}$ in.) in diameter. The 12 mm. rods are also tied to the 36 mm. bars by 3 mm. ($\frac{1}{8}$ in.) wire, as may be seen in the views Figs. 23 and 28. This reinforcement was completely encased in concrete. The effective wedging of the 12 mm. rods in the web of the voussoirs prevents all risk of slipping of the concrete in a direction parallel to that of the ribs. Owing to the length of the spans, the 36 mm. bars are in three lengths of about 20 m. (65 ft.) each, connected together by turnbuckles which, after adjustment, were welded up by the oxy-acetylene blowpipe. At their terminal at the skewbacks the 36 mm. bars were bolted to steel brackets, themselves bolted to the bearing plates of the arched ribs, as shown in Figs. 18, 19 and in the view Fig. 27. By this means the bars in question share all the stresses to which the lower chord is submitted and effectively lighten the work on the latter.

The building in of reinforced concrete slabs, in order to connect together the arched ribs along the soffit and underneath the track comprised the following: The slab at the soffit (Fig. 16) is 0·10 m. (4 in.) thick; the thickness is increased at each of the four arched ribs. The reinforcement is distributed in two layers 65 mm. (2·6 in.) apart. The lower layer of the reinforcement—the principal one—comprises 12 mm. rods which pass underneath the lower flanges of the ribs and round the 36 mm. round bars. These rods are connected with the other 12 mm. rods which run through the web of the ribs and in which they are firmly wedged. The longitudinal reinforcement of this lower layer is of 6 mm. ($\frac{1}{4}$ in.) rods, centred 0·20 m. (8 in.) apart. In the centre of the arch this longitudinal portion of the lower layer is supplemented by 26 mm. (1 in.) round bars, 0·20 m. apart. The upper layer is formed of 6 mm. rods, 0·20 m. apart both longitudinally and crosswise (see Figs. 11, 15, 16 and 23). The soffit slab enables inspection to be carried out easily at any time without the aid of scaffolding. A reinforced concrete slab 0·10 m. (4 in.) thick has been built on the extrados line over a length of about 6·50 m. (20 ft.) from the end of each span; on this rests the spandrel concrete casing work referred to below. This slab also serves to connect the arched ribs together and facilitates inspection. The reinforcement of this slab, made of 6 mm. and 12 mm. rods, is like that of the soffit slab, distributed in two layers 0·65 m. apart. At the springing the longitudinal reinforcement of the lower layer consists, over a length of about 3 m. (9 ft. 10 in.), of 26 mm. (1 in.) round bars, 0·20 m. apart. The slab underneath the track has throughout a thickness of 0·16 m. ($6\frac{1}{4}$ in.) not including the transverse ribs, Fig. 17, which are 1·10 m. (43 in.) apart between centres, and whose object is to consolidate in a vertical plane the four arched ribs, and to transfer a portion of the live load to the two outside ones. The main reinforcement of these slabs and ribs consists of 12 mm. and 22 mm. ($\frac{1}{2}$ in. and $\frac{7}{8}$ in.) round bars (see Fig. 17 and views Figs. 22 and 25). The 22 mm. bars run through the intermediate and the side arched ribs; they are held in the former by wedges, and to the latter by bolts.

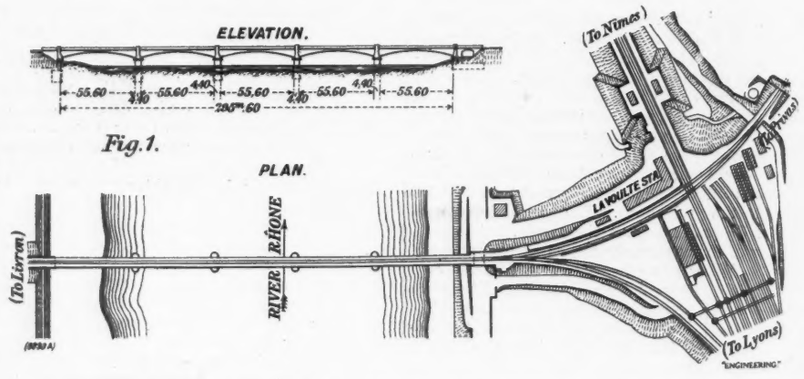


Fig. 1.

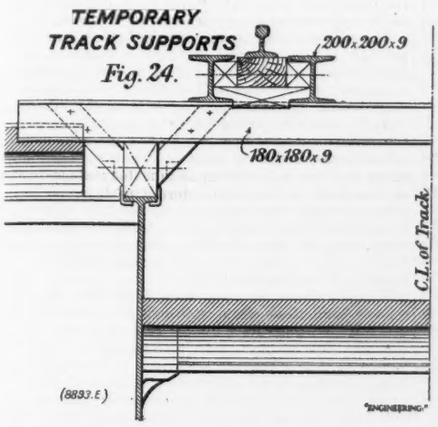
The ends of the slabs underneath the track cannot be connected to the masonry work of the piers and abutments owing to the movement of the ends, due to changes of temperature. The transverse stability of the ends can only be ensured by the stiffness of the spandrel framing, especially of the last spandrel vertical located directly in line with the end voussoirs on the skewbacks. With a view to strengthen the spandrel framing, and stiffen it sufficiently, the six last sets of spandrel braces have been embedded in reinforced concrete designed to form a very stiff structure, particularly in a transverse sense (see Figs. 8 and 26).

Both with a view to facilitate repair work, and to allow of placing the slab underneath the track at a suitable level, so as to provide for its connection with the arched ribs and the spandrels, the track was raised by 0·60 m. (about 2 ft.) from the commencement of operations, and it has been left at this higher level. Traffic was not interrupted while this was done; the track was supported on temporary sleeper girders of 5·30 m. (17 ft. 6 in.) span, carried on transverse joists which rested on the arched ribs and spandrel frames, as shown in Fig. 24.

All the steel and iron parts which were to be encased in concrete were first treated by sand-blast. The whole of the concrete was made of Portland cement. The sand and gravel used were taken from the bed of the Rhone. The proportions were 400 kilos (882 lb.) of cement, with 400 litres (14 cub. ft.) of sand, and 800 litres (28 cub. ft.)

THE REPAIR OF LA VOULTE CAST-IRON RAILWAY VIADUCT.

M. DE BOULONGNE, CHIEF ENGINEER.



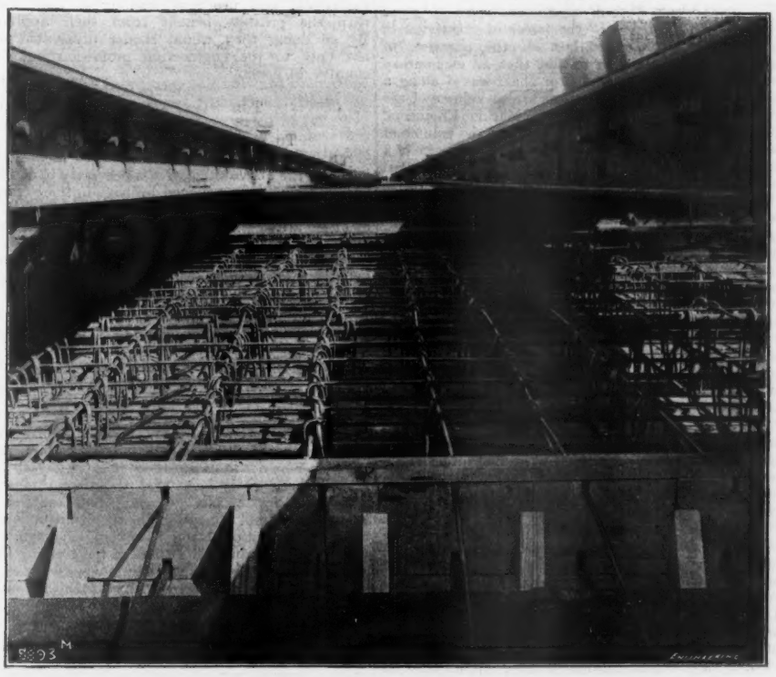


FIG. 25. REINFORCEMENT OF FLOOR SLABS AND RIBS.

FIG. 27. ATTACHMENT OF 36-MM. FLANGE BARS AT SKEWBACKS.

FIG. 28. ATTACHMENT OF 36-MM. FLANGE BARS TO VOUSSOIR SECTION WEBS.

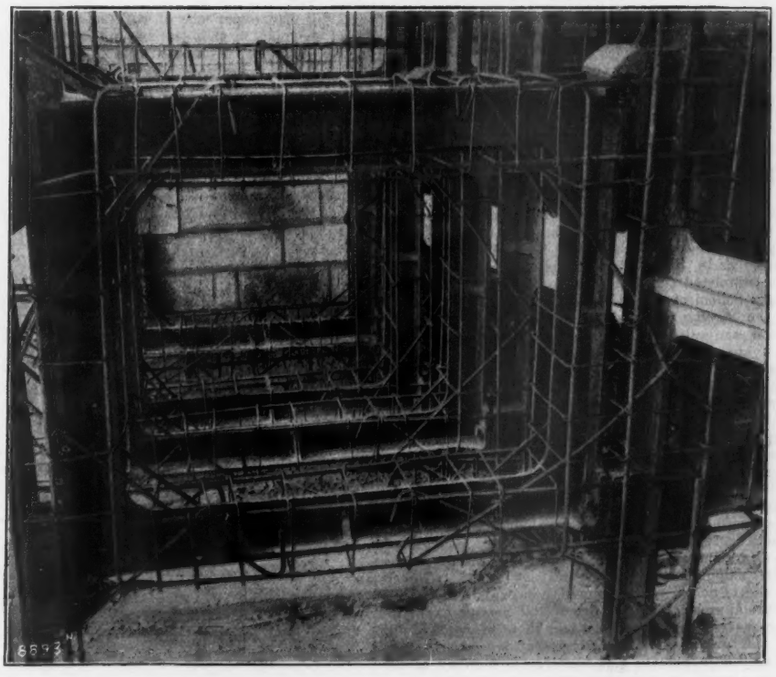


FIG. 26. REINFORCEMENT OF SPANDREL BRACINGS.

of gravel. This corresponds to about 1 : 1·6 : 3·2 by volume.

Electric arc welding was resorted to for repairing a number of damaged cast-iron parapet uprights. The raising of the track led to the raising of the footpaths, and the parapet had to be raised accordingly, as shown in the view, Fig. 22. Cast-iron extension pieces were electrically welded on the top of the parapet verticals, and through these a handrail is run. All cracks remaining in the cast-iron parts in the viaduct were filled by electric welding.

When the repair work was completed, the viaduct was subjected, as shown in the view, Fig. 3, to tests with heavy live loads, which it withstood quite satisfactorily. The total cost of the repair and strengthening work is not expected to reach the estimated figure of 2,000,000 francs, or less than half the cost of a new viaduct.

M. de Boulongne, Chief Engineer of Roads and Bridges, and Chief Structural Engineer to the Paris-Lyons-Mediterranean Railway Company, is to be congratulated on having originated the scheme, and on having carried it to a most successful issue.

LETTERS TO THE EDITOR.

FLYWHEELS AND TORQUE PULSATIONS.

To the Editor of Engineering.

Sir,—With reference to the letter of "Query" in your issue of January 16 last on the question of torque pulsations, I wish to add that an elementary treatment of the transmission of shear waves along a shaft is given on page 95 of the current volume of the Transactions of the Institute of Marine Engineers. The effect of this wave alone is to distort the volume of the shaft, and it is further shown that the presence of a coupling along such a length of shaft retards the impulse along the shaft.

Should a flywheel be included in such a shaft system, there will be a number of related considerations requiring examination before a full appreciation of the question can be obtained. In the treatment mentioned, it is shown that the rate of propagation of these waves depends on the rigidity and density of the medium traversed; therefore, the combination of a steel shaft and a cast-iron flywheel would suggest the possibility of a differential term, and this might cause a change in the amplitude of the motion in question. Should this latter factor enter into any particular case, it would depend on the surface traction between the shaft and wheel, which in turn would require an intimate knowledge concerning the method of securing the flywheel on the shaft. Lastly, the cutting away of the shaft for the keyways, &c., would call into being a force along the length of the shaft and acting over the boundary surface of propeller shaft. Your correspondent will recall that the existence of this "warping" effect was an important factor in the theory of St. Venant for non-circular shafts under torsion.

A full investigation of any particular case would seemingly call for an extended experimental examination of the effect of the flywheel section taken *normal* to the axis of the shaft, as well as the effect of various methods of fixing the flywheel to the shaft, on the persistence of the variation of torque beyond the flywheel.

From these considerations, it does not appear unreasonable to find variations of torque beyond the flywheel, as measured from the engine side. Is it not more reasonable to suppose that the presence of a flywheel and its connections retards the transmission rate along the shaft of the stress waves rather than sensibly reducing the amplitude of these variations? Of course, this retarding effect may manifest itself by a change of amplitude, but that does not alter the principle suggested.

Yours faithfully,
D. Laugharne Thornton.

Bromley House, Shipley, January 27, 1925.

THE WHITWORTH SCHOLARSHIPS.

To the Editor of Engineering.

Sir,—Kindly permit me to offer a few remarks on your article dealing with recent Whitworth Scholarship successes published in Engineering dated November 18, 1924. Being an ex-dockyard apprentice who completed the whole course of instruction in the Upper School of one of H.M. Dockyards I feel proud of the results achieved in the recent examination, which unquestionably proves the superiority of the dockyard system of training. I am confident that the Admiralty, and especially the teaching staff of the dockyard schools, will appreciate the prominence you have given in your columns to their particular methods of instruction, because it is doubtful whether the majority of commercial employers are aware of the educational facilities offered and the advantages accruing from them.

The methods of admitting apprentices into the dockyards and the opportunities given for enabling them to acquire a comprehensive knowledge of engineering practice, together with the compulsory attendance at afternoon and evening classes, constitute, in the writer's opinion, the principal reasons for the continued success of dockyard students in these examinations. To secure apprenticeship, an open Civil Service examination has to be passed, and it is here that the qualifications of the average dockyard apprentice exceed those employed in private concerns, for how many of the latter insist on the same educational standard as is required by the Admiralty establishments? The theoretical instruction, with its free provision of text and note books and other necessities, relieves the apprentices, on their restricted weekly wage, of all financial obligations, a concession which few other apprentices enjoy.

The vigorous weeding-out system mentioned tends to stimulate keen rivalry between the apprentices, and ultimately secures for the successful ones a course in the drawing office and a round of the various departments. Such opportunities as these rarely exist in private factories: the apprentices are almost exclusively engaged on a quantity production basis, and their main consideration is to earn as large a wage as possible. It is, therefore, essential for private engineering works to provide similar facilities for theoretical and practical training if they wish to reap the greatest benefit from their apprentices. By so doing they would render invaluable service not only to the engineering profession but to the country in general.

Yours faithfully,
Tom Park, A.M.I.E. (India) Calcutta.

To the Editor of Engineering.

Sir,—In discussing the points raised in the original letter on the above subject, it is necessary to commence with the education received by boys in the elementary schools of dockyard towns as compared with those in other areas. The classes in the upper part of the school are really converted into special coaching—one might almost say, cramming—classes in preparation for the Civil Service examination for apprentices in H.M. Dockyards. These boys are taught by well qualified and *more highly paid* teachers, many of whom have degrees or who at least have passed the Inter B.Sc. examination of London University. The competitive spirit amongst the schools themselves is of the keenest, and the elementary schools, in the past, have run the local secondary schools and junior technical schools very close for the first ten positions.

The examination is fixed at such an age (15-16) that it has the most important effect of *raising the school leaving age to nearly* 16 in these dockyard towns. It will therefore be seen that these conditions make it possible for a boy to get what amounts to a secondary school education in an elementary school, the only exception being a foreign language. Practical work is an important part of the training in such elementary schools, and the equipment is often quite good and has the additional advantage that much of it is made by the boys and teachers. The greatest possible care is taken to see that boys are very well advanced in mathematics, elementary mechanics and science. In the dockyard schools themselves there is a general air of hard work and the great majority of students have ever in mind the process of elimination, which is extraordinarily severe, as is instanced by the fact that of about 350 who commence the first year course, only about 12 are left in the fourth year.

Having had experience of both sets of students, I am of the opinion that the amount of time spent in private study by the dockyard apprentice far exceeds that spent by his brother apprentice in other towns. When to this is added the fact that apprentices in the upper dockyard school have a very large amount of time for "lugging up," as they themselves call it, and that the foremen use the "Nelson eye" when looking in their direction in the shops and on the ships, one can easily see why the dockyard student beats others in the race. Apprentices in their fourth year are allowed the same facilities for private study, for in this year all that is required of them is a specimen drawing. It will thus be understood that the student who is fortunate enough to get four years in the upper school is not likely, in general, to be such a good craftsman as the man who has "gone back to his tools" at the end of the first or second year, or anything like as good as the apprentice in a private engineering firm.

The technical schools and colleges in dockyard towns provide laboratory and lecture courses for these apprentices and the work is of a really advanced character; much more so than that provided in most other towns. The latter can, of course, do this advanced work if there is a demand for it, but generally speaking, the ordinary apprentice has such a poor knowledge of mathematics that he finds it difficult to follow anything beyond the ordinary elementary stages. The obvious reply is that the evening schools should themselves provide the mathematics, but my experience is that this type of student will not take the pill at this stage, and the time for administering such is in the higher tops of elementary schools, in central schools or in junior technical schools.

A comparison between men from the dockyard schools and those from universities shows that, in general, the former have not such a good general education, and their ability to write up reports is not anything like so good as is that of the latter. In consequence of this, such men suffer when applying for posts later on in life and even if called up, generally speaking, do not impress people who are interviewing them. The number of dockyard apprentices who take their degree is fairly small, because they are handicapped on account of the fact that they have taken no foreign language in any part of their training. Since the war there has been a much higher proportion of degree men among the ex-apprentices from H.M. Dockyards because of the fact that a number were enabled to take the war matriculation under Statute 116 of the University of London.

I am, Sir, yours faithfully,
Lawrence W. Kershaw.
Head of Mechanical and Civil Engineering Department, Loughborough College.

January 27, 1925.

VANE-WHEEL PROPULSION OF SHIPS.

To the Editor of Engineering.

Sir,—Permit me to revert to my letter in your issue of September 1, 1922. With the kind assistance of my friend, Mr. Martin, formerly of the Patent Office, I have been able to obtain from the Patent Office, a copy of David Napier's Specification of 1841. The early proposal for screw paddle-wheel propulsion of vessels, illustrated in Figs. 1 and 2, is not only interesting in itself, but would appear to speak very well for the Patent Office records that it was possible to supply a Patent Specification more than 80 years old.

Yours faithfully,
W. Sisson.

Gloucester.

Fig. 1.

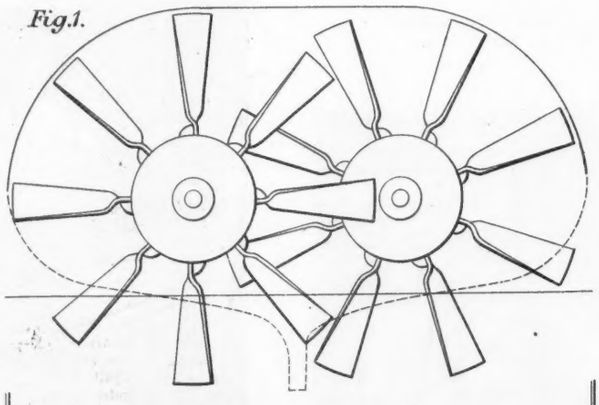
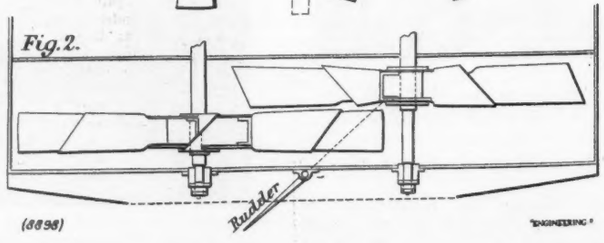


Fig. 2.



THE FIRST HEAVIER-THAN-AIR FLIGHT.

TO THE EDITOR OF ENGINEERING.

SIR,—The popular Press, from *The Times* downwards, was engaged last month in celebrating the "coming-of-age of the aeroplane" in view of the fact that Mr. Orville Wright, on December 17, 1903, made a flight of twelve seconds' duration at Kitty Hawk, U.S.A., in a "man-carrying power-driven vehicle."

May I be allowed the hospitality of your columns to remind your readers that the first flight of a "heavier-than-air" machine, with operators on board, took place in our county of Kent on July 31, 1894, or more than 9½ years before the exploit of the Wright Brothers?

On that occasion Mr. (later Sir Hiram) Maxim did actually fly on an aeroplane, weighing 8,000 lb. with its crew of three operators, measuring 104 ft. across the corners of the wings, and operated by steam engines of 360 h.p.—a daring piece of design. I had the interesting experience of a run on this machine at a later stage in the experiments.

Mr. Maxim was content, at that time, to achieve flight in a straight line. His machine, after taking off from a rail track, engaged in guides the object of which was to control the direction of flight, as Baldwyn's Park, where the experiments were going on, was heavily timbered.

On the date mentioned, after flying entirely free of the ground for more than 400 ft., the lift became so severe that the guide rails were torn up and Mr. Maxim found himself released into free flight in dangerous surroundings. He shut off both engines and the machine landed, damaging itself severely in the broken guide-rails. Those interested may refer to your issues of August 3 and 10, 1894, for a description of the machine and an account of the flight.

Yours faithfully,
W. MCGREGOR ROSS.

Kenley, Surrey, January 31, 1925.

MISSING PRESSURE AND HEAT LOSS IN GAS ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to Dr. Walker's suggestion in the current issue of your Journal to the effect that the surface of the silver grid in my explosion reached a temperature of 2,000 deg. C., I think he will at once be convinced that this was quite impossible when it is pointed out that a paper lining in an explosion vessel showed no signs of charring after an explosion was made in it.

Yours faithfully,
W. T. DAVID.

Engineering Dept., The University, Leeds.
February 2, 1925.

INTERNAL GAUGE FOR CYLINDERS.

THE accompanying illustrations show a useful form of gauge specially intended for rapidly checking the accuracy of the bores of motor-car and other engine cylinders, although also capable of being applied for measuring the variation from some given standard of the diameter of any hole within its range. Fig. 1 shows the appearance of the gauge, and Figs. 2 and 3 illustrate its construction and use.

It consists, as shown, of a steel tube carrying at one end a crosshead, and provided at the other end with a dial gauge. Into one end of the crosshead, a fixed steel distance piece, terminating in a steel ball, is clamped, as shown in Fig. 2, and the other end of the crosshead is fitted with a spring plunger. The inner end of the latter bears against the hemispherical end of a short quadrant-shaped rod, which works in a corresponding hole in a metal block forming the centre of the crosshead, while the other end of the quadrant-shaped rod, which is also hemispherical, bears against the lower end of a long steel rod located axially in the main steel tube of the instrument. The upper end of the central rod presses on the plunger of the dial gauge, and it will be understood that, with the arrangement of the parts described, any longitudinal movement of the spring plunger on the crosshead will be transmitted to the dial gauge and indicated by the rotation of the pointer of the latter. Backlash, it should be explained, is taken up by means of springs which are arranged so as to keep the whole of the moving parts firmly in contact.

In using the instrument for gauging a number of cylinders, it is first set to the standard diameter by means of a fixed gauge or micrometer calipers. To enable this adjustment to be made, a set of fixed distance pieces increasing in length in steps of 5 mm. is supplied with the instrument, together with a set of three washers, 1, 2, and 3 mm. in thickness, respectively. By the use of these distance pieces and washers, the length measured between the outer ends of the spring plunger and the distance piece can be made equal to the required standard diameter to the nearest millimetre above that diameter. In the final adjustment by the fixed gauge or micrometer, the spring plunger is pressed into the exact diameter, and while in this position the dial of the dial gauge is rotated so as to bring the zero of the scale opposite to the pointer in whatever position it may have come to rest. If, after this adjustment has been effected, the instrument is inserted in a cylinder, as shown in Fig. 2, the pointer of the dial gauge will indicate the extent by which the diameter varies from the standard by taking up a position on one side or other of the scale zero. The scale is graduated to read in either direction from the zero, so that the reading gives directly the amount by which the cylinder is too large or too small. This reading may be either in hundredths of a millimetre or in thousandths of an inch, quite irrespective of the fact that the distance-pieces are made to metric measurements.

It will be noticed from Figs. 1 and 3 that the instrument is provided with a spring-mounted guide bar

FIG. 1.

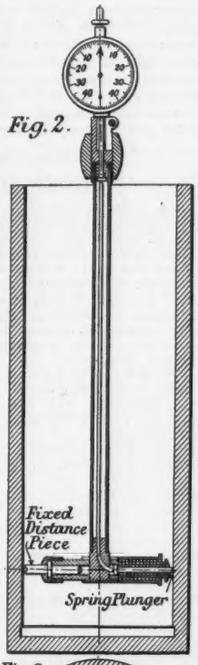


Fig. 2.

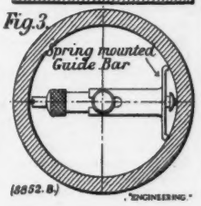


Fig. 3.

which consists of two arms projecting laterally from a sleeve sliding on the crosshead. The ends of the guide bar, which is quite narrow, rest on the inner surface of the cylinder walls when the gauge is in use, and serve to locate the measuring parts, *i.e.*, the spring plunger and the distance-piece, in the axial plane of the cylinder. To obtain a true reading of the diameter, however, it is also necessary to ensure that the axis of the measuring parts is at right angles to the axis of the cylinder. This can readily be done by slightly swinging the upper part of the instrument from side to side in the plane of the crosshead until the reading of the dial gauge is a minimum. This motion, it will be understood, causes one end of the crosshead to slide up and down in contact with the cylinder wall, while the other end remains stationary, and the minimum reading will obviously be obtained when the axis of the measuring parts is exactly at right angles to that of the cylinder. As shown in Fig. 1, the main tube of the instrument is fitted with an adjustable vulcanite holder, the object of which is to prevent the heat of the user's hand from causing the tube to expand; any variation in the length of the tube would, of course, affect the readings of the instrument.

In practice, the operation of gauging a cylinder at several points in its length can be carried out very expeditiously after the gauge has once been set, so that it would appear to be particularly useful for repetition work. The instrument is known as the "Subito" cylinder gauge, and is made by Messrs. Hahn and Kolb, of Stuttgart, the agent in this country being Mr. A. E. Menuge, Worplesdon, Surrey. The seven different sizes made are suitable for gauging holes ranging from 20 mm. to 400 mm. in diameter.

ELECTRICALLY-OPERATED BILLET SHEARS.

WHEN heavy billets are reduced in cross-section by the process of rolling, it eventually becomes necessary to cut them, either to finished size on completion, or to obtain lengths which can be handled in the later rolling processes. It is, therefore, essential to provide facilities for this purpose near to the rolls. Since the steel may be of considerable width and thickness when this cutting work has to be done, the machines installed must be capable of heavy and continuous duty. Speed of operation is another essential requirement as, to secure efficient working, the shearing should be done so that little opportunity is given in setting the steel in position in the machine for the metal to cool down. For this reason the machine must be arranged so that it can be rapidly set to cut to the required dimensions and, in fact, it should have characteristics, in this respect, equal to those of any first-class machine tool. The illustrations on page 166 show two views of such a machine which was designed and constructed by Messrs. Duncan Stewart and Co., Limited, of London-road Iron Works, Glasgow, for the State Steel Works of a foreign government, through Messrs. Sale and Co., London, and Messrs. Sale and Frazer, Limited, of Tokyo.

These shears are of the electrically-driven type, performing their work by up-cutting, and have some special features of undoubted interest. The drive is obtained from an electric motor of 150-h.p., made by the Lancashire Dynamo and Motor Company, Limited, of Trafford-park, Manchester. It runs continuously and the motion is taken through a coiled-spring clutch, immersed in oil, and gives anything up to 20 strokes a minute to the shears. Included in the equipment there is a heavy flywheel, the kinetic energy of which is partly used in the cutting process, to prevent excessive loads being put upon the motor. At every stroke of the shears it is possible to cut a billet 18 in. wide and 8 in. thick, but the stroke and capacity of the machine are suitable for dealing with billets up to 10 in. thick at the maximum speed.

The lay-out of the machine will be appreciated from the two illustrations. Mounted on a heavy bed-plate are the driving motor, the flywheel and the gears to obtain suitable speeds for the universal shaft which carries the drive through to the camshaft, by the rotating of which the motion is obtained for the shears. The motor shaft is coupled to a forged steel pinion, and the flywheel shaft is mounted with its axis in the same line. From the pinion the drive is taken by a cast-steel gear wheel to the second shaft, on which there is also a pinion driving the universal shaft, through the large wheel which is seen on the left hand-side of Fig. 1, and the right-hand side of Fig. 2. For the accommodation of these components on the bed-plate, machined faces are provided and the various parts were, on erection, registered in position to obtain correct alignment. The slow-speed shafts are supported in square-backed gun-metal steps, with which quick adjustment is possible. The top and bottom knife holders and the top crosshead, through which the motion is conveyed from the cam, are made of cast steel and are all guided on adjustable wearing surfaces on the cast-iron shear standards. When a hot slab or billet is placed ready for cutting, the camshaft is put into action and the top knife falls until it rests upon the metal. The bottom knife then rises and the metal is sheared, and when this operation is completed the knives return to their normal positions. Supported in brackets bolted to the standards is a hydraulic cylinder provided with a piston and rod to push the crop ends off the shear through the side openings of the vertical frame. This arrangement possesses the advantage that the carrying of the crop ends over the roller table is obviated.

There is a run-out roller table provided, as a deflecting table is not required with an up-cutting type of shears. For this table the rack frames are of cast iron and made with troughs in which the mitre wheels run. These troughs are covered with plates, which complete the enclosure of the gears which run in oil. All the bearings are of the ring-oiling type and have square backed steps to permit of rapid adjustment, while the mitre wheels have split clips, and therefore any wheel and roller may be lifted out when necessary without disturbing the rest of the table. The two front rollers are rotated by a spring-loaded drive of the builders'

design, and the whole table is worked by a 20-h.p. electric motor, made by the Lancashire Dynamo and Motor Company, Limited, through totally enclosed gearing. The stop and its associated measuring gear are controlled by an electric motor of the same make. From Fig. 1 it will be noted that the stopper arm is supported on a round fixed shaft which is of ample size to resist the very severe stresses produced by the striking of a heavy slab or billet against the stopper arm, when moving at the maximum speed at which the roller rack conveys it. To permit the steel billet to pass the stopper arm when the cutting is completed, the arm is lifted out of the way by means of a square shaft operated by an electric motor through reduction gearing. The arrangement of this gear is such that the stopper arm cannot come into contact with the roller gear, and there is a device introduced to ensure the safety of the gear when the arm is inadvertently lowered on to the top of a slab. Setting to any length between 3 ft. and 18 ft. may be accomplished by means of a quick-pitch screw to which is fitted a buffer arrangement to absorb the axial load produced when a slab strikes the stopper arm. A slipping coupling is introduced into the motor drive for this screw, and allows the full load of the motor to be slipped when the machine is handled carelessly.

The shear is operated, as has already been stated, through a coiled-spring clutch running in a flooded oil chamber, an arrangement which enables the load to be picked up without shock and also released during the actual cutting, if desired. To arrest the moving parts quickly when the clutch is released and thus add to the control of the machine, a brake rim is provided on the clutch. Another provision to protect the plant is a safety device which disconnects the flywheel when the maximum load is exceeded. This serves as a protection against heavy overloads should the material be fed in at too low a temperature. Another feature that calls for comment is the use of a universal spindle to connect the driving gear to the rising and falling camshaft. By this means, overhung wheels are avoided, and all of those used may be supported in rigid bearings, while the camshaft is relieved of heavy bending loads and the deadweights to be balanced are reduced. For the purpose of avoiding shocks at all parts of the stroke, particularly when the knives are brought to rest and when the slab is sheared, a hydraulic balancing system is introduced. In addition to the advantage derived from the balancing system, it also has the feature that it can be used, in combination with the rotation of the camshaft, to obtain a powerful grip for holding the slab during the cutting, and thus avoids the use of the usual complicated and delicate holding-down gear.

THE OPTICAL SOCIETY.

At a meeting of the Optical Society held at the Imperial College on Thursday, January 15, 1925, a paper, entitled "*A Peep into Sir William Herschel's Workshop*," was read by Dr. W. H. Steavenson. It described the results of a recent examination of such instruments and apparatus of the great astronomer as are still preserved at Slough, where the bulk of Herschel's optical and astronomical work was done. The mirror of the 40-ft. telescope was mounted on its edge against the wall of the entrance hall of Observatory House. The surface had suffered much from exposure while in the telescope, and was affected all over by a fine pitting. It was not, however, greatly tarnished or discoloured, and still gave a recognisable reflection of suitably lighted objects. It was, unfortunately, impossible to test the figure in such a confined space, and the great weight of the speculum (about a ton) prevented it being moved elsewhere for this purpose. The mirror of the 20-ft. was in very good condition, but its present figure was due not to Sir William but to his son, Sir John Herschel, who took it with him to the Cape and there last polished it as recently as 1837. The figure, as tested in 1924, was found to be very even, but markedly hyperbolic, or over-corrected; but the great focal length of the mirror made this defect less serious than it would otherwise have been.

Among the smaller mirrors there were several made of glass, and these Herschel had used for observing the sun. One was of particular interest, being made of "white glass" and having somewhat the appearance of a china plate. Some of the metal mirrors, of 9 in. diameter and 10 ft. focal length, were found soldered down in tin cases, and when opened, proved to be in remarkably fine condition as regards their polish. Foucault tests were made of all the mirrors, most of which were found to be of fair to good figure, though several were affected by zones of long or short focus. There were thirty flats in all. Close-fitting covers had maintained the polish of most of them in good condition. No test of the truth of their surfaces had yet been made. Forty-eight eyepieces, apart from micrometers, were found in the collection. All were of the single-lens form used almost exclusively by Herschel.

Several were of very short focus ($\frac{1}{16}$ in. to $\frac{1}{16}$ in.), which was of interest in view of the doubts often expressed with regard to the high powers reported to have been used occasionally by Sir William. The 7-ft. telescope was still in fair working order. A zonal test of the mirror by Foucault's method showed the correction to be very good, and this was borne out by actual observations of stars and planets. The definition was excellent, being equal to that of any modern reflector of similar aperture. The only defect was in the light-grasp, which had been impaired by tarnish. It was, however, still equal to that of a 3-in. refractor.

The second paper was entitled "*Speed Precision Training Gear Governed from a Distance*," and was read by its author, Dr. P. P. Schilovsky. The paper stated that increase in precision in the training of telescopes, microscopes, &c., is possible only if an electrical device, controlled from a distant station, is applied to the moving parts. It is essential that the angular velocity of the training motor should correspond with that of the handle of the manipulator. Standard motors in which the speed of rotation depends upon load and output cannot be used; the only system available is one where the manipulator can revolve the magnetic field of a motor's element in strict conformity with the speed and direction of a distant device at the governing station.

BOOKS RECEIVED.

United States Geological Survey. Bulletin No. 750–C. *Observations on the Rich Silver Ores of Aspen, Colorado.* By E. S. Bastin. No. 756. *Oil and Gas Fields of the Lost Soldier Ferris District, Wyoming.* By A. E. Fath and G. F. Moulton. [Price 20 cents.] Washington: Government Printing Office.

Motor Manual. Vol. I. *Automobile Engines in Theory, Design, Construction, Operation and Maintenance.* By Arthur W. Judge. London: Chapman and Hall, Limited. [Price 4*s.* net.]

Research Department, Woolwich. R.D. Report No. 60. *Gun Wire. The Effect of Low-temperature Heat Treatment on the Properties of Cold-drawn Steel Wire and on its Behaviour and Stress at Raised Temperatures.* London: His Majesty's Stationery Office. [Price 2*s.* 6*d.* net.]

Wireless Working Hints for Beginners. By Archibald Williams. London: Percival Marshall and Co. [Price 1*s.* 6*d.* net.]

The South Wales Coal Annual, 1925. Edited by C. B. Hailey and D. Willson Lloyd, M.A., F.S.S. Cardiff: The Business Statistics Company, Limited. [Price 12*s.* 6*d.* net.]

A Study of the Locomotive Boiler. By Lawford H. Fry. New York and London: Simmons-Boardman Publishing Company.

The J. and P. Transformer Book, being a Practical Technology of the Power Transformer. By S. Austen Stigant, M.I.E.E., and H. Morgan Lacey, B.Sc. London: Johnson and Phillips, Limited. [Price 5*s.*]

Die Gewinde ihre Entwicklung, ihre Messung, und ihre Toleranzen im Auftrage von Ludw. Loewe & Co. A.G. Berlin. By Dr. G. Berndt. Berlin: Julius Springer. [Price 36 gold marks.]

United States Bureau of Standards. Technologic Papers No. 262. *Comparison of American and Foreign Clays as Paper Fillers.* By M. B. Shaw and G. W. Bicking. [Price 15 cents.] No. 264, *Development of the Standard Numbered Cotton Duck Specification. Study of Methods of Tests and Tolerances.* By C. W. Schoffstall and R. T. Fisher. [Price 10 cents.] Washington: Government Printing Office.

Humanism and Technology and other Essays. By Principal C. Grant Robertson and others. London: Humphrey Milford. [Price 3*s.* 6*d.* net.]

United States Bureau of Labour Statistics. Bulletin No. 375. *Safety Code for Laundry Machinery and Operations.* Washington: Government Printing Office.

Mechanical Engineering. By R. S. McLaren. Fifth edition, revised. London: Charles Griffin and Co., Limited. [Price 6*s.* net.]

Outlines of the Occurrence and Geology of Petroleum. An Introductory Handbook. By I. A. Stigand, M.A., F.G.S. *With an Appendix on Geophysical Methods as Applied to Oil-Finding.* By M. Muhlberg, Ph.D. London: Charles Griffin and Co., Limited. [Price 10*s.* 6*d.* net.]

Regulation of Rivers without Embankments as Applied in the Training Works at the Headquarters of the Rangoon River, Burma. By F. A. Leete, C.I.E., and G. C. Cheyne. London: Crosby Lockwood and Son. [Price 30*s.* net.]

The Institution of Naval Architects.—It is announced that the council of the Institution of Naval Architects have awarded the gold medal for the year 1924 to Engineer-Commander R. Beeman for his paper on "Further Experimental Work on Diesel Engines," and the premium for the same year to Professor K. Suyehiro for his contribution on "The Drift of Ships Caused by Rolling Among Waves." These awards will be presented at the Annual General Meeting to be held on April 1, 1925.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel Trade.—Conditions are so exceptionally mixed that it is difficult to represent accurately the main tendencies of the staple trades. Leading authorities lose no opportunity of stressing the necessity for increased confidence both as between employers and workmen and buyers and sellers. To the maintenance of a spirit of quiet optimism is largely attributed the improvement, slow but sure, witnessed in several of the leading sections during the past twelve months. At the same time, very substantial progress remains to be made before anything like remunerative working is restored in a general sense. Chief among the deterrent factors are the prevailing high rates and taxes, transport and fuel charges, dock charges and rising tariffs in foreign markets that formerly ranked amongst the principal recipients of Sheffield steel and tools on export account. Unemployment in the staple trades has undergone a steady decline during the past four years, but there are still, according to the latest official returns, some 24,000 operatives either wholly unemployed or working only two or three days a week. A large proportion of these are believed to consist of unskilled or semi-skilled labourers who entered Sheffield on munitions service during the war period. On home account a big tonnage of basic steel is being produced, but more orders are required for export to enable plants to operate profitably, and these are difficult to obtain in face of the keenness of foreign competition and the uncertainty of the industrial outlook in Germany. All kinds of rolling stock and wagon furnishings constitute an active line. British automobile engineers are big buyers of structural steel, parts, fittings, and magnetos. Business with French automobile engineers has sustained a set-back from the uncertainty caused by the new French tariff measure, though opinion that many of the proposals embodied in this Bill will be rejected tends to become stronger every day. Improving sections are those producing builders' ironwork, mining tools, and general engineering materials.

South Yorkshire Coal Trade.—Despite weak spots, the prevailing undertone of the market is one of quiet strength. Quotations are mainly unaltered, and, having regard to reduced output, there is not great pressure on sales. Steam coal is expected to improve as the home railway companies build up their reserves. There is no immediate prospect of any favourable change in the export situation. A steady call is experienced for better quality slacks and washed smalls, but there is little business passing in cobbles and nuts. House-coal supplies are ample to meet requirements. Quotations:—Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 19*s.* 6*d.* to 23*s.*; Derbyshire hards, 19*s.* 6*d.* to 22*s.*; rough slacks, 9*s.* 6*d.*; 12*s.* nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The position as regards Cleveland pig iron alters very little. Sales are on only a moderate scale, and are mostly for home purposes, but a few small parcels have been sold to Continental customers, and America is inquiring after foundry descriptions as well as the special qualities usually sent to the States. No. 1 is offered at 84*s.*, No. 3 g.m.b. is easy at 79*s.*, No. 4 foundry is quoted 78*s.*, and No. 4 forge is put at 77*s.*

Hematite.—East Coast hematite keeps fairly steady, notwithstanding the handicap of rather heavy stocks, and in this branch also a few Continental inquiries are circulating, whilst hope is entertained of fairly good business with America in the near future. Nos. 1, 2 and 3 are on sale at 86*s.* 6*d.*, and No. 1 is quoted 87*s.*

Foreign Ore.—Imported ore is deadly dull, and it is difficult to ascertain on what terms contracts might be arranged. Sellers base market rates on best Rubio at 22*s.*, c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is quietly steady. Moderate sales are being made to local consumers. Good average qualities are in the neighbourhood of 24*s.* delivered here.

Manufactured Iron and Steel.—Most descriptions of manufactured iron and steel are slow of sale, but in one or two branches there is some expansion of inquiry. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 9*l.*; steel joists, 9*l.* 5*s.*; heavy steel rails, 9*l.* 10*s.*; and galvanised corrugated sheets (24 in. gauge, in bundles), 17*l.* 10*s.*

Imports of Iron and Steel.—Interesting statistics issued this week by the Tees Conservancy Commission give the imports of iron and steel to the Tees from Holland, Belgium, France, Norway, Sweden, Germany, India and coastwise for the three months ended January 31 last, together with the figures for the same three months a year ago and for the corresponding pre-war period of 1913-1914. Pig-iron unshipped in the past three months is returned at 3,684 tons, as against 1,691 tons for the same three months a year ago, and 50 tons in the pre-war period; crude sheet bars, billets, blooms and slabs un-

loaded in the past three months reached 31,542 tons, as against 11,175 tons a year ago, and 11,200 tons in the pre-war period; and plates, bars, angles, rails, sheets and joists imported to January 31 totalled 3,736 tons, as against 3,147 tons a year ago, and 5,869 tons in the pre-war period.

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees ports during January totalled 83,935 tons, 31,186 tons being pig-iron, 13,439 tons manufactured iron, and 39,310 tons steel. Of the pig-iron shipped 17,959 tons went coastwise, and 13,227 tons went abroad; of the manufactured iron cleared, 7,400 tons went coastwise and 6,039 tons went to foreign ports; and of the steel despatched, 10,479 tons went coastwise and 28,831 tons went overseas. Scotland was by far the largest customer for pig-iron, taking 14,216 tons; whilst America received 3,445 tons; Denmark, 2,781 tons; Germany, 2,153 tons; and Wales, 1,950 tons. The Cape of Good Hope and Natal were the heaviest purchasers of manufactured iron, importing 3,794 tons and 1,752 tons respectively. The principal receivers of steel were: India, 6,724 tons; Argentine Republic, 3,297 tons; Queensland, 2,736 tons; Japan, 1,880 tons; Natal, 1,725 tons; Burma, 1,640 tons; New South Wales, 1,580 tons; Victoria, 1,488 tons; and Hong-Kong, 1,280 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the steel trade of Scotland are again very dull this week and movement is of a very limited nature. Consumers are not too well booked themselves and are, consequently, not in a position to place many orders, and production at the local steel works is therefore far from full. Part of the demand which does exist is being filled by material from the Continent and also by some from the south, and another cause of the quietness is the reduced activity in the shipyards. All classes of material for the latter are in poor demand. In the black sheet trade the particular bright spot is galvanised sheets, and numerous inquiries are in circulation. Some of the producers are booked a good distance ahead and are slow to fix up much more at present. Heavy sheets are not very active but a fair business is going through. The general export trade is far from good. The following are the current prices:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; sections, 9*l.* 10*s.* per ton; and sheets, $\frac{3}{16}$ in. to $\frac{1}{4}$ in., 12*l.* per ton, all delivered at Glasgow stations.

Malleable Iron Trade.—No improvement of any kind falls to be reported in connection with the bar iron trade of the West of Scotland this week. Not only is the demand very poor but inquiries are far from holding out any prospect of an early change for the better in the home trade. The export side of the business is extremely quiet, but there are a few more inquiries. The steel bar sections are doing tolerably well at the moment and billets of foreign manufacture are being freely used. Prices are unchanged, with "Crown" bars at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—There has been no change for the better in the Scottish pig-iron trade and fresh business is very scarce. Stocks are increasing all round owing to the poor demand, both on home and export account. In the latter connection there is actually very little doing and inquiries are on a very small scale. The following are the market quotations:—Hematite, 4*l.* 15*s.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 12*s.* 6*d.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, January 31, amounted to 821 tons. Of that total 799 tons went overseas and 22 tons coastwise. For the corresponding week of last year the figures were 1,017 tons overseas and 60 tons coastwise, making a total shipment of 1,077 tons.

Shipbuilding.—It cannot be said that the outlook in the shipbuilding industry is any too bright at present. Work on hand is not very plentiful and only two or three fresh contracts were reported during the first month of the year. The cost of construction is too heavy at present for owners to be entering the market for cargo tonnage, and the prospects of these being less is not very bright owing to the demands of shipyard workers and engineers. The new tonnage launched during the month of January was quite up to the average. It consisted of the following:—

	Vessels.	Tons.
The Clyde	8	28,566
The Forth	1	200
The Tay	1	4,900
Total	10	33,666

The Clyde total compares with nine vessels of 36,917 tons for January of last year, but is 30,000 tons under the figure for January, 1922.

RAILWAY MAP.—For the assistance of manufacturers and traders throughout the British Isles, the London Midland and Scottish Railway Company have issued in booklet form a classified list of their goods stations in 2,592 towns, together with a large key map, size 3 ft. by 2 ft., showing station positions on the system. In addition, useful information is given regarding bonded stores, warehousing accommodation, &c.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 6 p.m., at Storey's-gate, S.W.1. Extra General Meeting. "Anti-Friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus. Friday, February 13, at 7 p.m. Informal Meeting. Discussion on "Gear Production Machinery."

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—To-night, at 6.30 p.m., at the Engineer's Club, Coventry-street, W.1. "Flying in Australia," by Mr. J. L. J. Hinkler.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette. "The Measurement of Hardness and Allied Properties of Metals," by Mr. Edward G. Herbert. Friday, February 13, at 7.30 p.m. Hon. Member's Lecture. "Milestones in the Development of the Prime-Mover Locomotive," by Mr. Loughnan Pendred.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH. Saturday, February 7, at 4 p.m., at the Grand Hotel, Aytoun-street, Manchester. Lecture. "Psychological Examination of Foundry Life," by Mr. V. C. Faulkner. At 6.30 p.m. Annual Dinner.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, February 7, at 7.15 p.m., at the Municipal Technical College, Park-street, Hull. Lecture, "Recent Developments in Marine Auxiliaries," by Mr. J. Sim, B.Sc.

THE SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE.—Saturday, February 7, at 7.30 p.m., at the Royal Technical College, George-street, Glasgow. "Steam Condensing Plants," by Mr. D. L. Hall.

THE INSTITUTE OF TRANSPORT: YORKSHIRE SECTION.—Monday, February 9, at 5.30 p.m., in the Council Room, Town Hall, Leeds. Lecture "Transport in Africa," by Sir John Eaglesome, K.C.M.G.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, February 9, at 5.30 p.m., at St. John-street, E.C.1. "Ball Bearings," by Mr. F. O. Moysey.

THE SURVEYORS' INSTITUTION.—Monday, February 9, at 8 p.m., at Great George-street, S.W.1. "Tube Railways," by Mr. F. Hunt. "Arterial Roads," by Mr. Sydney A. Smith. "Land returned by Government Departments," by Mr. C. Gerald Eve.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 10, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Paper to be submitted for discussion, "Considerations in the Development of Water Power, with Special Reference to India," by Mr. Bertram Darell Richards, B.Sc., M.Inst.C.E. Wednesday, February 11, at 7 p.m. Informal Meeting. Subject for discussion, "The Transport Layout of a Large Factory," to be introduced by Mr. Frank Turner.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, February 10, at 6.30 p.m., at 85-88, The Minories, Tower-hill, E.1. Presidential Address.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Tuesday, February 10, at 7 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH. BURNLEY SECTION.—Tuesday, February 10, at 7.15 p.m. at the Municipal College, Ormerod-road, Burnley. "Machine Tool Work," by Mr. H. Jowett.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, February 10, at 7.30 p.m., at 207, Bath-street, Glasgow. "Three-Wire Direct Current Distribution Networks. Some Comparisons in Cost and Operation," by Mr. H. W. Taylor.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, February 10, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. "An Investigation into the Effects of Cold Drawing on Some Properties of Iron and Steel," by Dr. Robert M. Brown.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, February 11, at 2.30 p.m., at the Old Colony Club, Aldwych House, Aldwych, W.C.2. Annual General Meeting. Presidential Address by Mr. Alcwyn A. Jones. Paper on "Unsettled Questions in Heating and Ventilation," by Mr. A. H. Barker, B.A., B.Sc., Wh.Sc.

THE ROYAL SOCIETY OF ARTS.—Wednesday, February 11, at 4.30 p.m., at John-street, Adelphi, W.C.2. Ordinary Meeting. "The Diesel Engine in Navigation," by Sir J. Fortescue Flannery, Bart, D.L., M.Inst.C.E.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, February 11, at 7.30 p.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W.1. Joint Meeting with the Chemical Engineering Group. "Internal Combustion Boilers," by Mr. Oscar Brünler. "Steam Generation under Critical Conditions," by Mr. David Brownlie, B.Sc.

THE INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, February 11, at 7.30 p.m., at St. Bride Institute, Bride-lane, Fleet-street, E.C.4. "Commercial Road Transport," by Mr. G. T. Sharpe.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Thursday, February 12, at 5.15 p.m., at 21, Albemarle-street, W.1. Afternoon Lecture. Sir William Bragg on "The Properties and Structure of Quartz" (Lecture III).

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN: BIRMINGHAM AREA.—Thursday, February 12, at 7.30 p.m., at the Chamber of Commerce, New-street, Birmingham. Lecture, "Boiler House Layout and Management," by Mr. Philip S. Woolley.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, February 12, at 7.30 p.m., at the Institute of Marine Engineers, 85-88, The Minories, Tower-hill, E.1. "Some Notes on Refractory Materials," by Mr. V. C. Faulkner.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, February 13, at 7.15 p.m., at the University College, Singleton Park. "Season Cracking and its Prevention," by Dr. H. Moore.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, February 13, at 7.30 p.m., at the Sheffield Metallurgical Association, 198, West-street, Sheffield. Conjoint Meeting of Societies. "Fuel and its Efficient Utilisation," by Dr. C. H. Lander.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 13, at 7.30 p.m., in the Lecture Theatre, Literary and Philosophical Society, Newcastle-upon-Tyne. "The Internal Combustion Locomotive," by Mr. J. W. Hobson.

THE INSTITUTION OF MECHANICAL ENGINEERS: YORKSHIRE BRANCH.—Friday, February 13, at 7.30 p.m., at the Philosophical Hall, Leeds. "Anti-Friction Bearing Applications for Heavy Duties," by Mr. J. B. Dahlerus.

THE DIESEL ENGINE USERS ASSOCIATION.—Friday, February 13, at the Engineers' Club, Coventry-street, W.1. "Submarine Engines and High Speed Heavy Oil Engine Electric Generating Sets," by Mr. P. A. Holliday.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The joint accountants of the workmen and owners for the South Wales coal trade in their report for December show a certified rate of 19·31 per cent. above the 1915 standard, compared with 18·78 per cent. in November. The December rate determines the wages payable in February, but as the minimum is 42·22 per cent. above the standard, the owners are compelled to pay the difference by the forfeiture of their share of the surplus and their standard profits, and also to draw upon reserves or further increase bank overdrafts. December is the seventh successive month in which the industry has been worked at a loss, the total loss over the period amounting to 897,000*l.* The output from January to April under the old agreement amounted to 16,844,612 tons, which was reduced in the four months ending August to 15,478,289 tons under the new agreement, and further lowered to 15,148,567 tons in the four months ending December. The wages cost of production in the four months ending April was 11*s.* 10·43*d.* per ton, which was increased in the eight months ending December to 13*s.* 4·50*d.* per ton, an advance of 1*s.* 6·07*d.* per ton. There was thus an increase in the wages cost and a decrease in output of 1,700,000 tons. The total cost of production in the first four months of the year was 17*s.* 9·75*d.* per ton, which was raised to 19*s.* 5·08*d.* per ton in the last eight months of the year, an increase of 1*s.* 7·33*d.*, which was just a little higher than the wages increase. Under the old agreement there was a credit of 1,730,000*l.*, or 2*s.* per ton, in the first four months of the year, out of which interest on debentures, bank interest, capital expenditure, amortisation, &c., had to be met. In the second four months of the year under the new agreement there was a loss of 430,000*l.*, or 6¾*d.* per ton, and in the last four months a loss of another 425,000*l.*, representing another 6¾*d.* per ton. In the six months ending June 29,850,790 man-shifts were worked, but in the last six months of the year only 28,297,832 shifts were worked, a decrease of 1,552,958 shifts. Moreover, in the first half of the year 1,513 coal-raising shifts were lost through lack of trade, estimating an output of 671,801 tons, but in the last six months 3,974 shifts were lost, representing an estimated output of 3,789,495 tons so that the number of shifts lost were increased by 2,461 and the estimated output by 3,117,694 tons. The quantity of coal exported from South Wales in the first six months of the year amounted to 13,133,286 tons, which was reduced by 584,054 tons to 12,549,232 tons in the second half of 1924. From these facts it will be seen that the new agreement has increased the cost of production, reduced the volume of exports, and increased unemployment.

Iron and Steel.—Exports of iron and steel goods from South Wales in the past week totalled 14,710 tons, compared with 19,880 tons in the previous week. Shipments of tinplates and terne-plates totalled 7,685 tons, against 6,430 tons; black plates and sheets 1,478 tons, against 3,364 tons; galvanised sheets 4,542 tons, against 4,083 tons; and other iron and steel goods to 1,012 tons, against 5,706 tons.

LONG-DISTANCE RADIO COMMUNICATION.—An unusual case of long-distance communication by means of wireless telegraphy has recently been announced. Using a Marconi M.C.1 type, 1½-kw. continuous wave-valve transmitter, the operator at the Japanese station in Chosi succeeded in transmitting a message to the American station in San Francisco, a distance of 4,500 miles, in daylight. The set in service at Chosi is one specially designed for ship installations as an addition to the spark transmitting apparatus and intended to communicate between ships up to a distance of 1,500 miles.

ELECTRICALLY-DRIVEN UP-CUTTING SLAB AND BILLET SHEARS.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 163.)

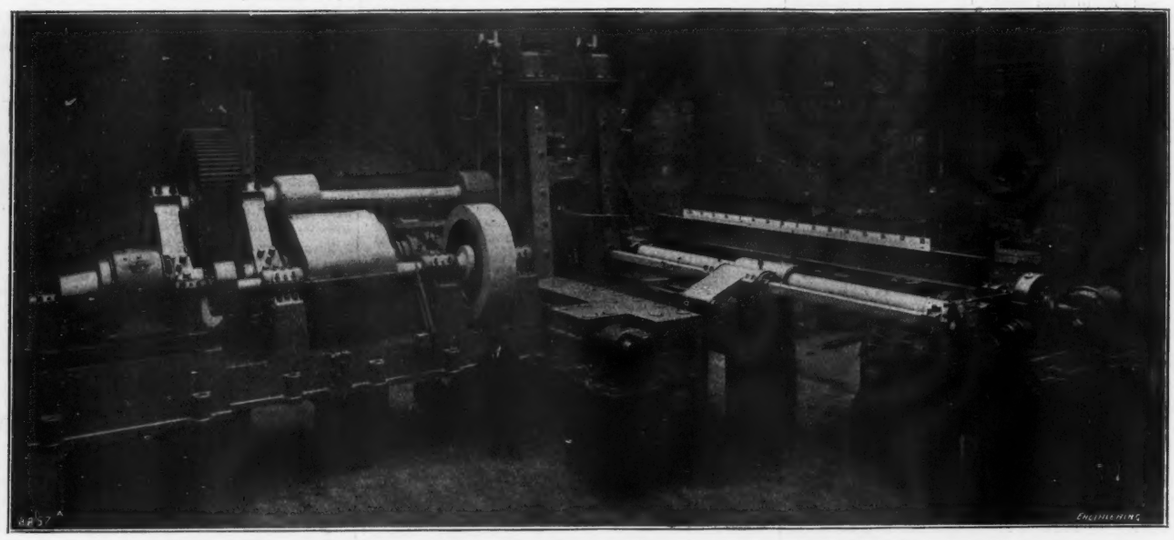


Fig. 1. View of Shears showing Motor Drive, Flywheel, Run-Out Table and Stop Gear.

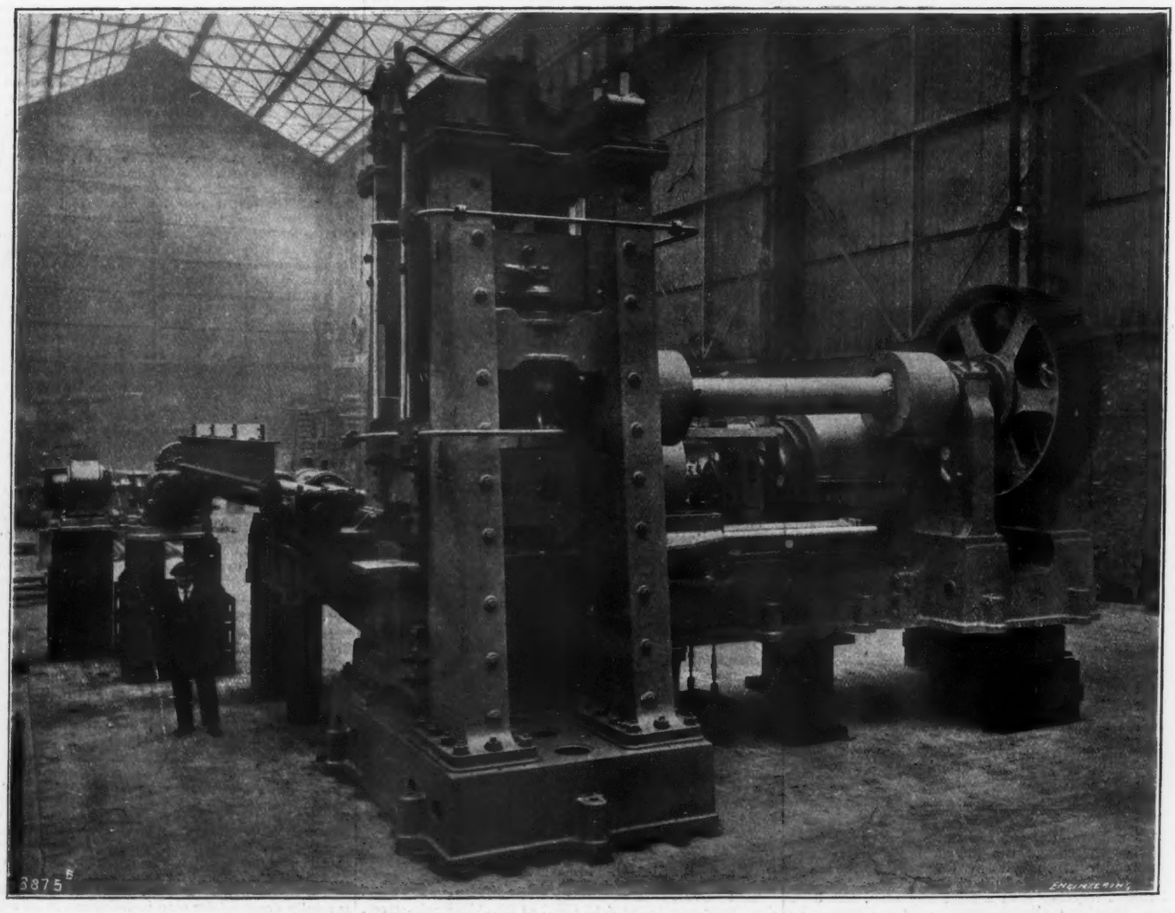


Fig. 2. End View of Shears showing Universal Shaft and Construction of Frame.

THE REPAIR OF LA VOULTE CAST-IRON VIADUCT OF THE P.L.M. RAILWAY, FRANCE.

M. DE BOULONGNE, CHIEF ENGINEER.

(*For Description, see Page* 159.)

FIG. 2. VIEW OF VIADUCT AS ORIGINALLY BUILT.

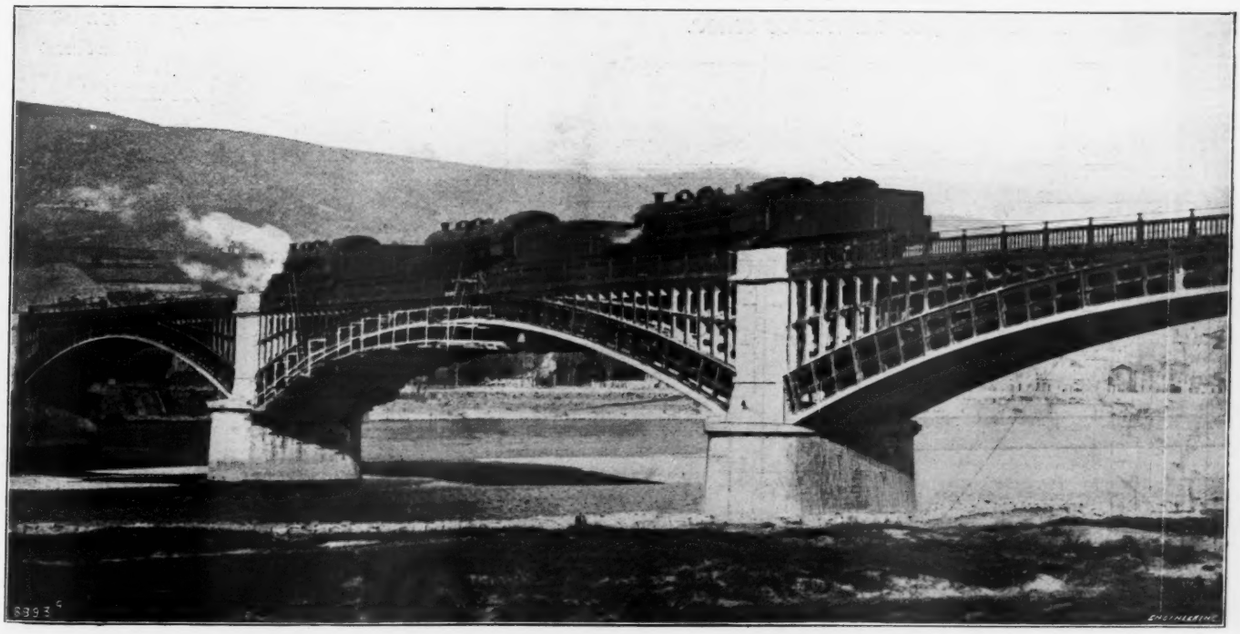


FIG. 3. VIADUCT UNDER TEST AFTER COMPLETION OF REPAIRS.

(*To face page* 160.)

THE REPAIR OF LA VOULTE CAST-IRON V[OUC]

M. DE BOULONGNE, [OF ENGI]

(For Description, Page 159.)

To Livron

Fig. 4.

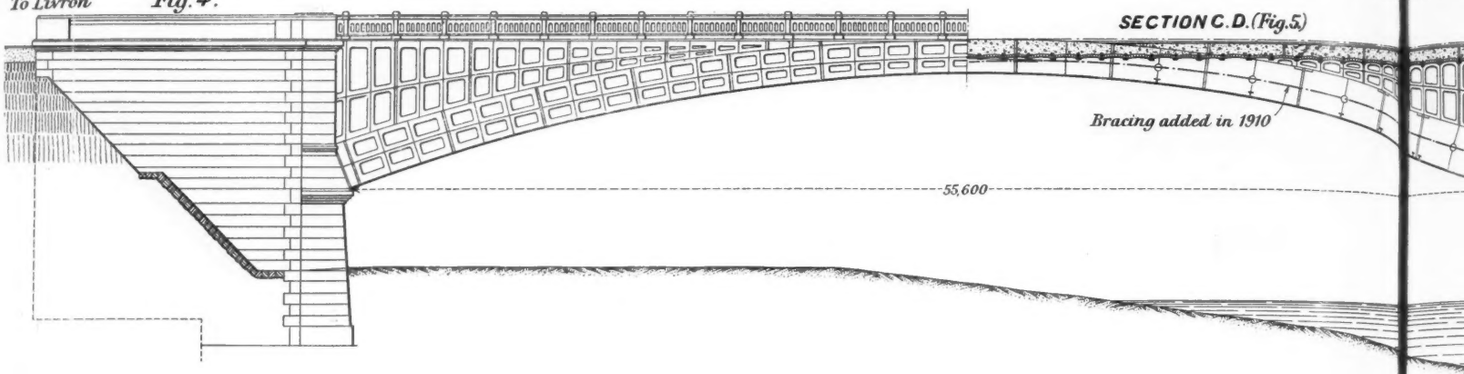


Fig. 5.

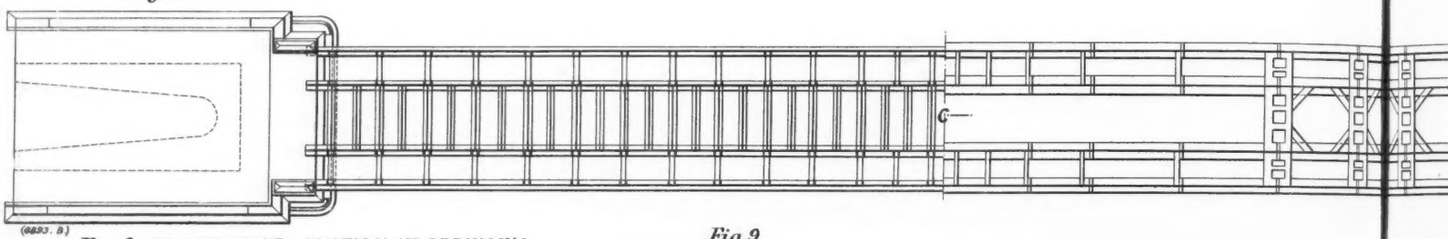


Fig. 8. TRANSVERSE SECTION AT SPRINGING

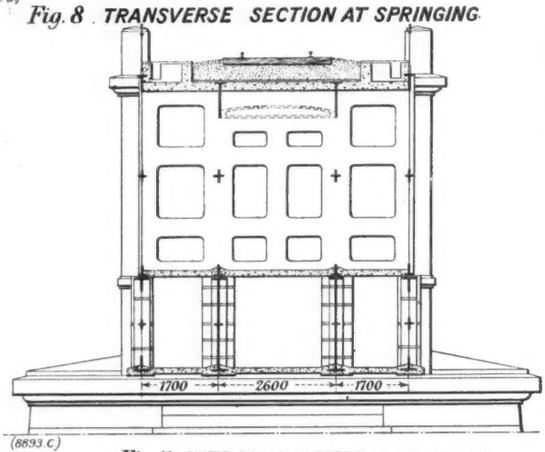


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Fig. 9.

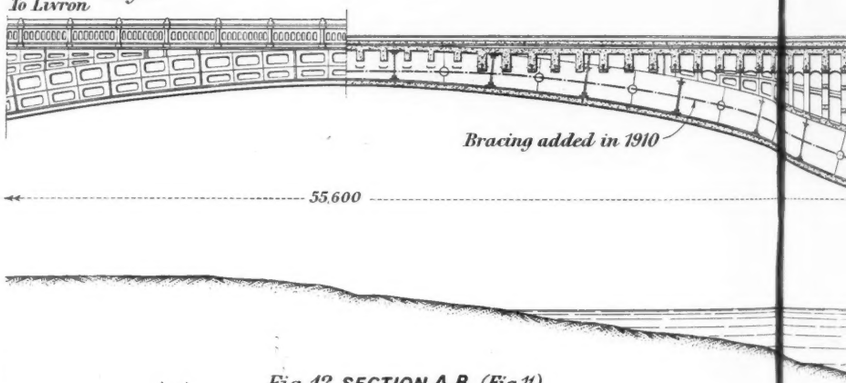


Fig. 11. INTRADOS & EXTRADOS SLABS.

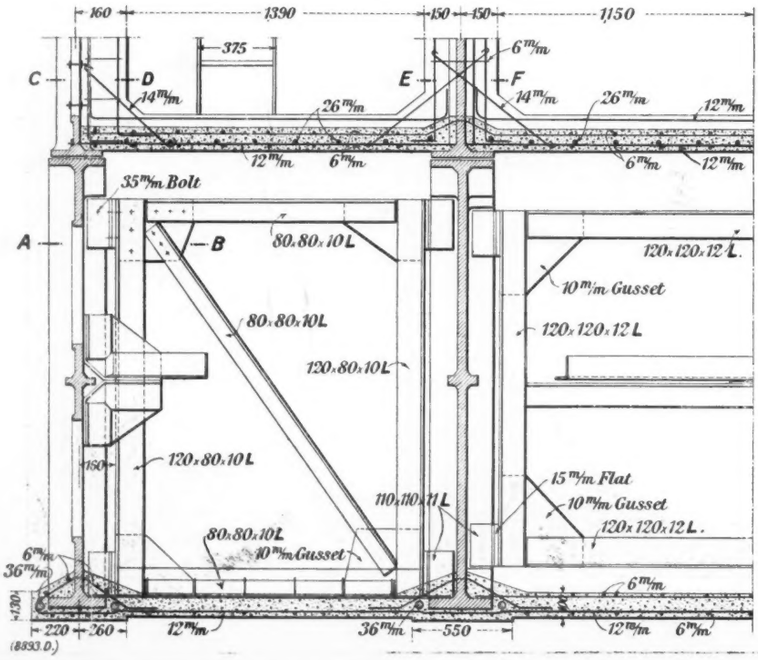


Fig. 12. SECTION A.B. (Fig. 11)

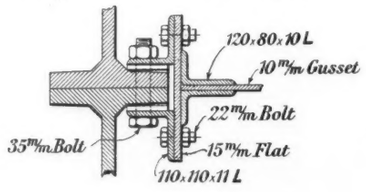


Fig. 13. SECTION C.D. (Fig. 11)

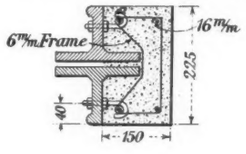


Fig. 14. SECTION E.F.

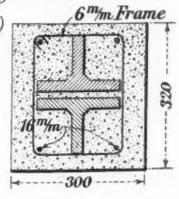


Fig. 17. SECTION G.H. (Fig. 15.)

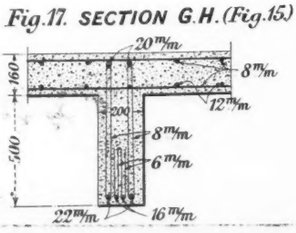


Fig. 15. TRA

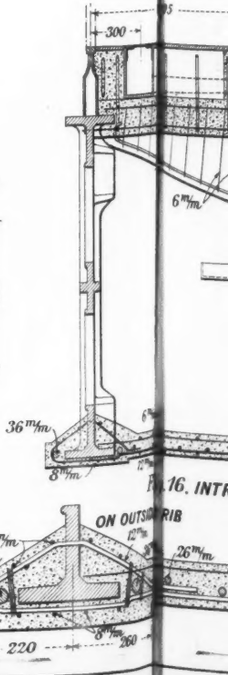
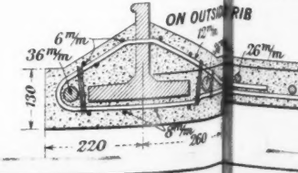


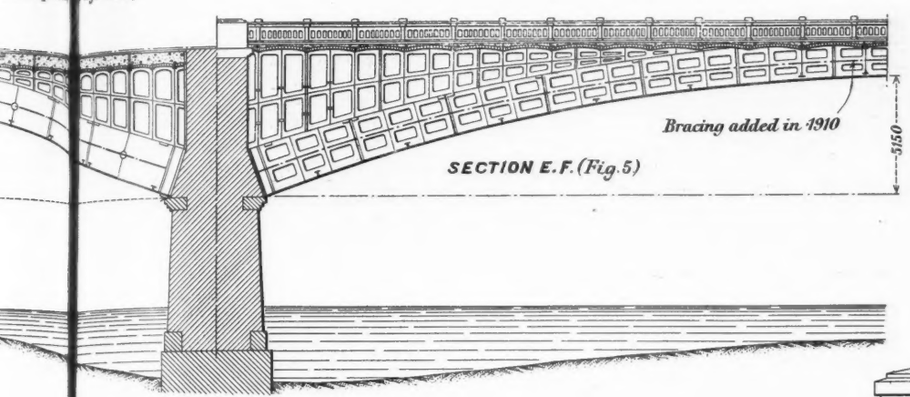
Fig. 16. INTR

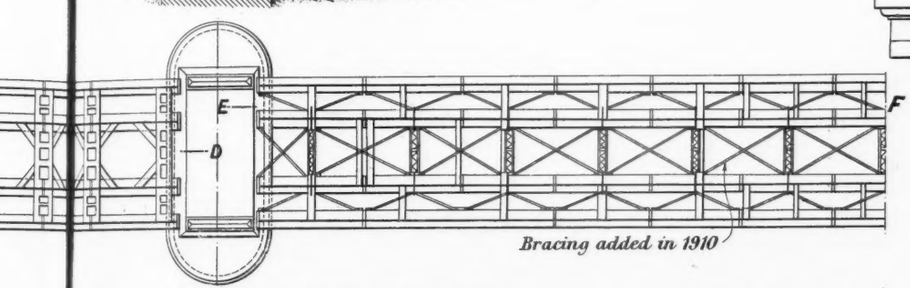


ON VIADUCT OF THE P.L.M. RAILWAY, FRANCE.

ULONGNE, CHIEF ENGINEER.

(See Description, Page 159.)





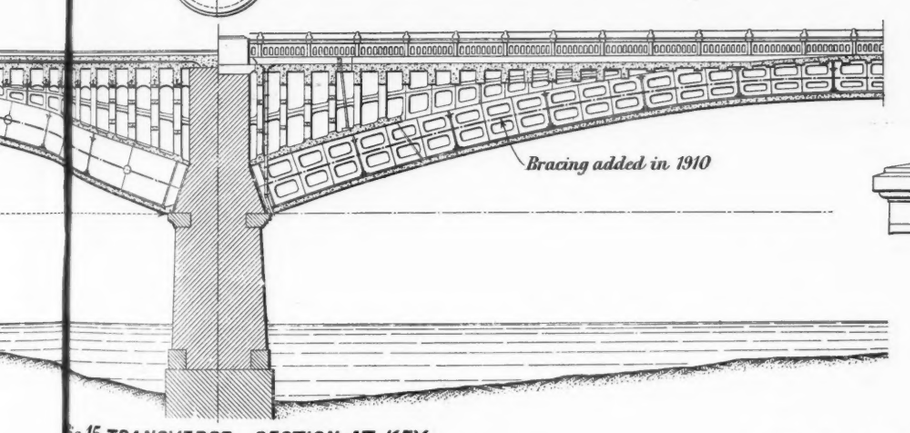


Fig. 6. SECTION IN FRONT OF A PIER

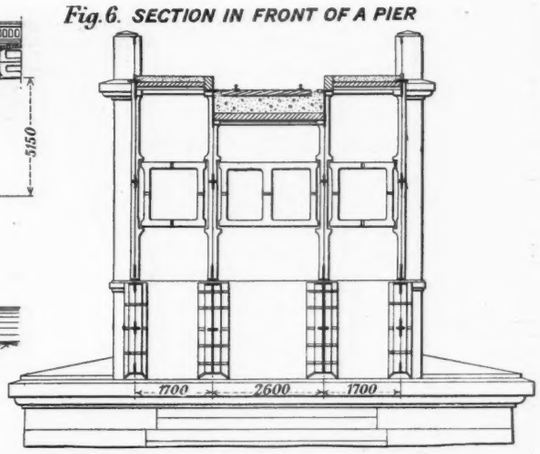


Fig. 7. SECTION NEAR CENTRE OF A SPAN

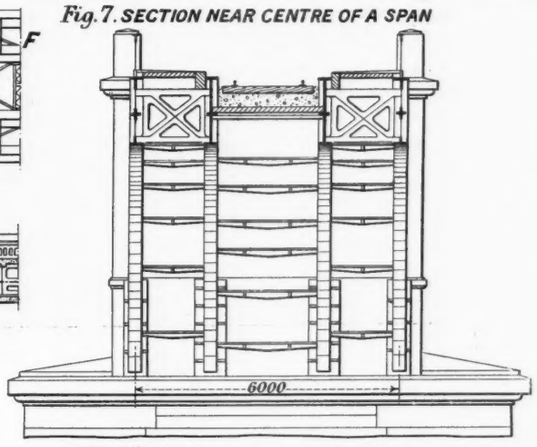


Fig. 10. TRANSVERSE SECTION AT KEY

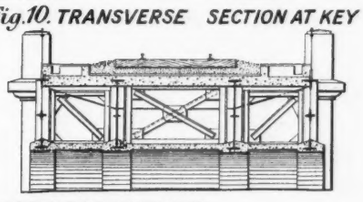


Fig. 15. TRANSVERSE SECTION AT KEY

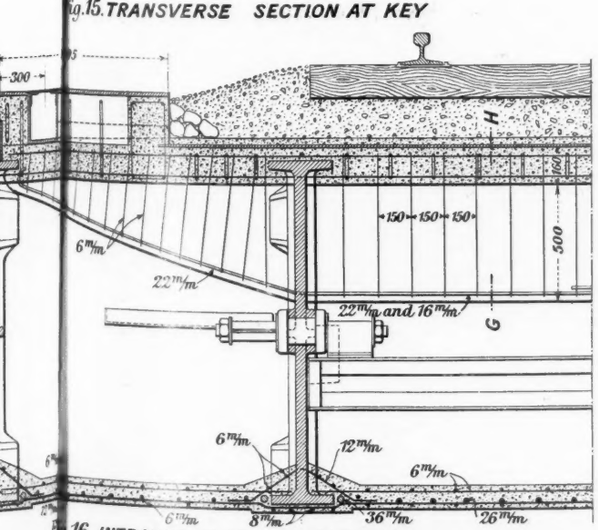


Fig. 16. INTRADOS SLAB CONNECTIONS

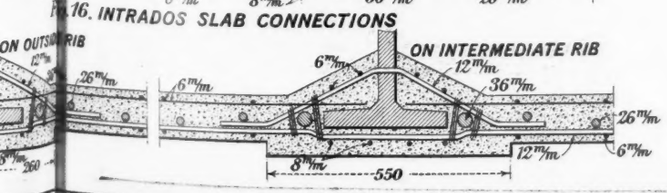
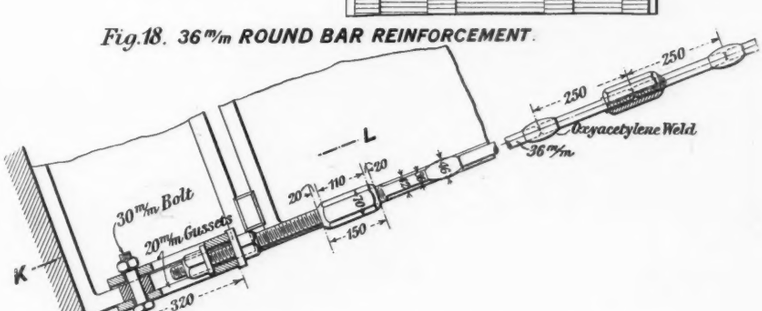
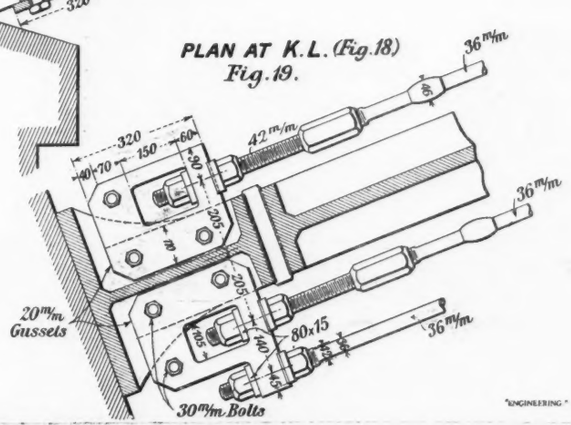


Fig. 18. 36 m/m ROUND BAR REINFORCEMENT.



PLAN AT K.L. (Fig. 18)
Fig. 19.



"ENGINEERING."

THE REPAIR OF LA VOULTE CAST-IRON VIADUCT OF THE P.L.M. RAILWAY, FRANCE.

M. DE BOULONGNE, CHIEF ENGINEER.

(*For Description, see Page* 159.)

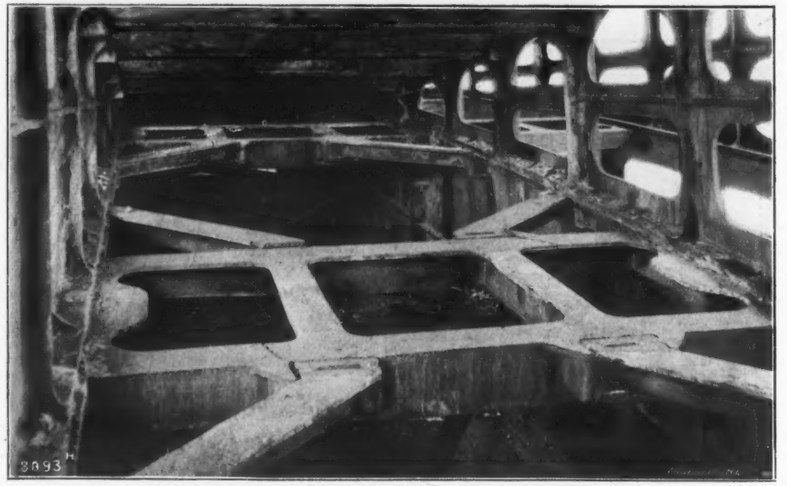


FIG. 20. VIEW SHOWING CRACKS IN CAST-IRON BRACING.

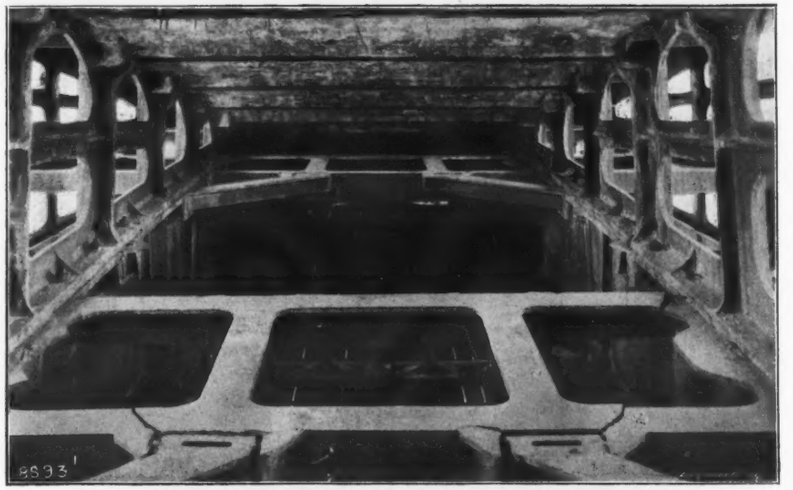


FIG. 21. VIEW SHOWING CRACKS IN CAST-IRON BRACING.

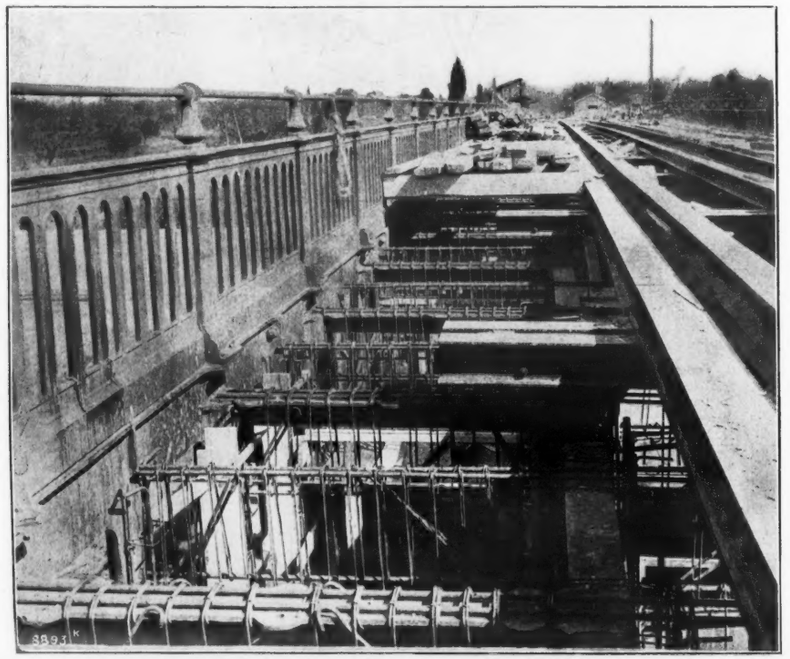


FIG. 22. REINFORCEMENT OF DECK BEAMS.

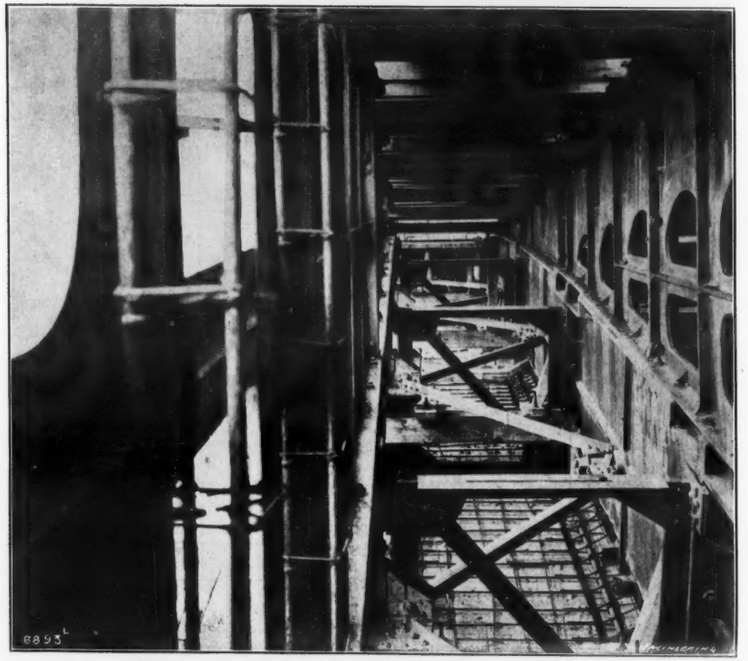


FIG. 23. REINFORCEMENT OF LOWER SLAB AND OUTER RIB.

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ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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One Two-Page Plate and Two One-Page Plates.—THE REPAIR OF LA VOULTE CAST-IRON VIADUCT OF THE P.L.M. RAILWAY, FRANCE.

ENGINEERING.

FRIDAY, FEBRUARY 6, 1925.

THE RIGHT TO WORK.

IN refusing to discharge a workman because he had ceased to belong to a trade union the Office of Works has asserted the doctrine that a good employer must not apply trade union tests to his workmen. That the union in question chose finally to withdraw its refusal to readmit its late member, and that he was willing to maintain the offer by which it was enabled to "save face," does not detract from the weight of the assertion; and it could hardly have been made at a more opportune time.

For among the many problems of industry, and in particular of the engineering trades, none is more urgent and more important than that of restoring to the workers of this country the right to work, of which they have been deprived in recent years. As things are, the number of unemployed men in the last two years has been beyond all precedent, and the country has not only been without the benefit of what they could have produced, but has had to add to overhead national charges that already are little short of intolerable, the burden of providing these men with some sort of support. Nor is the mischief confined to the production that is thus lost and the costs now being incurred. The country does not produce within itself all that it requires, and for the means of obtaining the balance has thus to look to supplying foreign markets with what they need. What this country does not supply to foreign markets competing countries will; and seeing that a market can be lost more quickly and more easily than it can be made or regained, this country, through insufficient or inefficient production, is not merely losing present orders, but is reducing its hold on future markets. The support of unemployed men in idleness draws similarly on future as well as on present resources. Most men to whom support is thus given resent the idleness that qualifies them to receive it, objecting to take what they have not earned. Often they could object on the more material ground that idleness, however involuntary, injures their ability to work. This ability to work is the chief asset of most individuals, as its aggregate is of the nation; and in taking toll of the nation's energy or power of work the grant of unearned support is weakening the nation's future as well as its immediate resources.

It is difficult to say what would have to be done if, by their individual wishes, the workers of this country really preferred to lose orders and markets, to spend the attenuated resources of the nation on supporting unemployed men in idleness, and to reduce through this inactivity the power of these men to do work in the future. It would be a choice among the several ways of bankruptcy. The country cannot feed its population off its own soil, and its industries, handicapped in this way in competition with those of better advised nations, would be unable to find the means of buying their food from abroad. The surplus population that could not live off the soil would have literally to starve or to emigrate. The actual means of emigration on a sufficient scale would not be available, and, even if they were, few parts of the earth are open to receive emigrants who are wholly destitute. This state of things would doubtless not be reached suddenly. It would be preceded by a gradual reduction of the standard of living, already much below that of the United States; but though the process would be gradual, it would be none the less inevitable, if for any reason the general body of workers of the country wished to do less than their best at whatever work they had to do.

It is, however, premature to consider this situation, for there is no evidence that the general body of workers have any such wish, and those who are best able to judge, believe they have not. It is, on the contrary, believed that it is against their will that for a long time past the workers in general have not been free to do what work they might wish, or to do and be paid for as much as they could. Merely to give them back this freedom would not be enough in all industries. In some, or perhaps most, industries many things would still remain for the employers of labour to do, but which they cannot obtain the means of doing so long as it remains uncertain whether men will be free to do their part. What, however, is certain is that without this freedom the industries affected are themselves unable to do their best, either in service to the community or competition with other countries. In a free country—unless it is under communist control—no man can be compelled to do work against his will, except in circumstances of national emergency. Every man is free to decline work; but the peculiar paradox of the present situation is that in this country men have not an equal freedom to accept it.

The consequence of this extraordinary restriction is seen in many industries; most notoriously perhaps in the building trades. In all parts of the country fresh building has been needed urgently for many years past. Perhaps no industry has work in sight for a longer period ahead, and has more jobs that could be done with a minimum of technical training. Yet no industry has set its face more rigidly against allowing work in it to be done indiscriminately by those who are competent to do it, or against accepting methods of payment that induce men to do their best, and reward them proportionately. The melancholy consequence has been that the already overtaxed resources of the State have had to provide subventions for work done at extravagantly inefficient rates. To the extent of these subventions the cost has been borne by the community and withdrawn from the resources available for promoting trade; the balance of the wasted energy appears in the form of increased rent, remains a charge on the owners or tenants while the houses endure, and has to be added to the figure of wages in the industries whose workers inhabit them. All the while there have been men able and willing to do the work, if they had been allowed to do so; to build the houses, stop the idleness, and save more than has been spent on the subvention of waste.

The policy that has succeeded in putting these restraints on men's freedom is defended broadly on two considerations. On the one hand it is held that if all men are set free to do any class of work within their power, those who already are doing a given class of work may some day be out of employment. The pretention that is used most often to support the demand for demarcation, is that each man's skill represents the result of a long apprenticeship and a lifetime's experience, entitling him to the same sort of vested interest in the exclusive right to practice his occupation and to prevent other men from doing so as, for example, a doctor has. The analogy is wholly inexact. The course of modern practice has steadily reduced the amount of skill that most men can use in the best factories, until now it is worth intrinsically far less than the common sense and character of a good unskilled labourer. To take the extreme case of the great shops in which the highest wages in the world are paid for engineering manufacture, 85 per cent. of the jobs in the Ford Company's shops are learned in anything from one day to a fortnight, nearly half of them in a single day, and no criterion of a man's fitness for a job is recognised except that he can do or learn to do it. In all shops, again, the choice of jobs to be offered to men is made by persons more expert in the job than the man himself, and the consequence of a mistake is no serious calamity; conditions that may be contrasted broadly with those in which a doctor is called in, with his patient dependent helplessly on the doctor's professional credentials in matters that may be of life and death. The other fallacy used to commend limitation of output—that the less a man does, the more work remains for the employment of other men—is now so generally discredited that it would be idle to recite the reasons by which it is condemned.

For the time being the remedy that seems most urgently needed is to restore to individual workmen their right to work, with no restrictions on its nature and quantity, or on the extent to which they may be paid in proportion to what they do. The existing system, with its legalised "peaceful picketing" and its allocation of trade union subscriptions to political purposes unless the member incurs the odium of demanding to be exempted, denies them that right. If in fact the workers wish individually the restraints that are imposed in their name, nothing will be altered by restoring this right; if they do not, the well-being of industry demands that it should be restored, and depends on adequate use being made of it. With workers free and determined to do the best they can the way will be clear for trade unions to devote themselves to their true functions. They will, it is to be hoped, co-operate in the discovery of means for making the energies of their members more productive, and employers will be able prudently to give effect to such means to that end as either they or the trade unions or both together may devise. This is doubtless not all that is necessary to maintaining and improving the present standard of life, but it is a condition precedent to most other measures, and in the engineering trades, in particular, is the most hopeful. The present situation is based on artificial restrictions of individual freedom. Under the pretexts described above it has been instituted in order to incite and enable various groups of men to struggle with their employers and with each other, and to these ends it has sacrificed the efficiency of the entire industrial army in its struggle with the economic forces of Nature and with competing countries. The right adjustment of the relations of men to their employers and to each other in the division of what is won from the earth must be secured without diminishing the amount of the values to be divided, or restraining the productive energy of any man who in any way can add to it.

STRAIGHT-FRAME SHIPS.

During the course of the European War, when it was necessary to build ships at an accelerated rate to make up the losses caused through submarine attack and mines, the adoption of straight-frames for ships, which could be prepared in the general steel constructional works and only assembled in the shipyards, proved of great service. Experience has shown, however, that not only in such "fabricated" ships was advantage to be gained in construction by the use of straight frames. Even for ships, where the whole of the steel work was prepared and erected in the ordinary shipyards, benefits could be obtained through this simplication of form. In practically all developments which tended towards progress, it was found that against the advantages that were obtained by making changes, there were certain disadvantages introduced which might assume great proportions if care and foresight were not exercised in getting out the initial designs. When experimental evidence was available of all the effects produced as the result of any change in constructional practice, the position from the designer's point of view was simplified, as investigations were possible before the building was attempted. This, as was pointed out by Dr. A. M. Robb in a paper on "Straight-frame Ships," which he read before the Institution of Engineers and Shipbuilders in Scotland on Tuesday, January 27, was the case in connection with vessels in which curved frames were avoided.

The original decisions of Sir Eustace Tennyson-d'Eyncourt and Mr. Thomas Graham in favour of the construction of straight-framed vessels, which they submitted to the Deputy Controller for Auxiliary Shipbuilding during the war, were based on experimental evidence that the simplified form need not offer much more resistance than the best curved-frame types. Once these decisions were made, investigations of a more extended nature were resorted to, in order to obtain more complete knowledge of all the effects of the simplification. Dr. Robb, in the paper to which we have already referred, discussed the results of these tests which were conducted as preliminary investigations prior to the decisions which led to the selection of the final design. Eight forms were chosen for experiment, representing vessels 400 ft. length between perpendiculars, 52 ft. in breadth, and of $24\frac{7}{8}$ ft. moulded draught. Though it was often contended formerly that the straight-frame form had a resistance which was unduly sensitive to the position of the chine line and that it was therefore much more likely that the designer would produce a bad straight-frame form than a bad curved-frame one, and although the chine lines of the models used in the tests at the William Froude Tank were very different, the graphs connecting effective horse-power and speed of the vessel did not show any great variations. The small sacrifices in propulsive performance due to the use of an angular bilge were largely removed in some of the straight frame vessels by taking a parallel chamfer off the bilge, the flanged bilge strake resulting being a product of the ordinary constructional works. In a shipyard, of course, the preparation of a radius bilge was possible, and its use on a straight-frame vessel was a perfectly sound proposition, giving, in some cases, a form actually better than a good curved-frame form of the same dimensions and displacement. For instance, in one case the straight frame ship with a suitable bilge showed a gain of about 5 per cent. in effective horse-power at $8\frac{1}{2}$ knots, which was gradually reduced as the speed was increased until it reached zero at 13 knots. Therefore it was contended that it was possible to use straight frames in association with a radius bilge for cargo boats and obtain vessels of at least as good a form as a curved frame ship.

Prior to actual use of the straight-frame vessels, it was commonly the case that they were regarded with suspicion by their officers, but experiences failed to substantiate their views, and favourable reports were made by them later, on the performance of the ships in rough weather. It was probably the case that small differences in form had little influence on the behaviour of ships at sea, and that the stowage of cargo was the greatest factor of all. In the best of the war-time constructions it was regarded as an objectionable feature that certain of the holds had to have V-shaped inner bottoms or excessively deep double bottoms. In the design of such ships the designers had to make a choice between sacrificing cargo space or convenience in stowage. These objections have now been removed by making the tank top level in the after holds and keeping it low in the forward hold. In this new design, the margin plate was run along the middle of bilge strake, and the bottom frame and shell bar of the frame heel bracket were bent to a radius. From the results of tank tests, and also from experiences at sea with ships of this improved form, no evidence was obtained to support the belief that a steep chine line was essential for satisfactory propulsive performance, for in this vessel the chine line was much flatter than that of any of the models originally tested. Comparison of the results from this vessel, which was built in 1922, with a similar curved frame one constructed in 1919, showed to the advantage of the straight frame form to the extent of 12 per cent. of the horse-power at a speed of $11\frac{1}{2}$ knots.

Constructionally, straight-frame vessels had, Dr. Robb considered, many advantages. Firstly, the scrieve board could be eliminated, which meant a not-inappreciable saving in shipyard outlay. Associated with this gain was a simplification of the off-set sheet, as it was only necessary to record the weather deck heights and half-breadths, the height of the straight chine lines at the centre, with the half breadths at the various stations, the bilge radius and the heights and half breadths of the upper knuckle in the after body. There was great scope for savings in shipyards costs, even if bevelling should involve heating. Straightening could be done without heating as also could the bevelling, judging from experiences with the latest class of the war-time vessels. Even assuming that it was necessary to heat straight-line frames for bevelling, their adoption at least assured the economy resulting from the smaller cost of straightening as compared with turning. The modern straight-frame ship was commonly straight-backed. Advantages due to the elimination of sheer were great. Deckhouses, casings, hatch side coamings, deck girders, panelling and doors all became rectangular when there was no sheer and were more easily laid off. In addition to this, the frames within the parallel middle body were all of the same length and were completely interchangeable. When straight frames were to be used, it was possible to finish the beam knees on the ground. There were, of course, considerable advantages obtainable when material could be prepared by reference to the mould loft rather than to the actual ship; the work could be done under cover and thus independently of weather conditions. The material could be dealt with as it came to the yard thus avoiding stoppage due to improper sequence in delivery. Formerly the shell plating was the most serious obstacle to complete prior preparation of the material. Although the triangulation method used in the development of the plates was not truly accurate, it was more so in the case of a straight-frame body plan than that using curved frames. Because of this, an increase was possible in the production of shell plates to form if straight frames were adopted. Improved organisation of the work of shipbuilding immediately became possible with this method of construction. An important point in its favour, from the standpoint of the shipowner, was the facility with which repairs could be effected in case of damage.

ECONOMIC CONDITIONS OF PANAMA.

The Republic of Panama was formerly a province of Columbia, but became an independent State in 1903. A mountainous strip of country some 32,000 square miles in extent, it has a total population of just over 440,000 inhabitants, most of whom are coloured, there being only 52,000 whites. Much of the country is undeveloped; indeed, portions of it are so little known that the timber resources of the Republic are still a matter of conjecture. Agriculture is limited, in spite of the fact that the soil is excellently suited for the cultivation of such crops as rice and maize. Cattle rearing is not conducted on a scale large enough for export purposes, and manufacturing is practically non-existent.

Panama is consequently in no sense a producing country, and this is abundantly demonstrated in

the Report of the Economic, Financial and Commercial Conditions of the Republic of Panama and the Panama Canal Zone, prepared by Mr. R. Keith Jopson, and issued by the Department of Overseas Trade. That the position of the country from an economic point of view is a peculiar one is shown by the fact that imports of foodstuffs and manufactured goods totalled 10,268,548 dollars in 1922, while exports for the same year amounted to only 2,487,479 dollars. This deficit is made up by money entering Panama by way of the Canal Zone; in other words, the Republic depends for its business largely upon the money spent by users of the canal and by officials, employees and others stationed in the Canal Zone.

Trade with Great Britain, although small in volume, shows a satisfactory upward tendency. Whereas imports from the United Kingdom were valued at 952,910 dollars in 1922, the figure for 1923 was 1,370,254 dollars. The bulk of the trade is, of course, in the hands of the United States, which, with 67·4 per cent. of the total value of imports, is far ahead of any other competitor. France came next to Great Britain, but with only about half the value of imports. British trade with the country scarcely touches engineering products, though it is interesting to note that business in small Birmingham hardware is developing, and that our galvanised sheets have also been able to compete with the American product, in spite of the cheaper freight from the United States. As regards exports, the values in most cases are small, the United States taking the bulk of the more important products. It may be noted that of the total exports of balata, valued at 22,360 dollars, Great Britain purchased 93 per cent., the balance going to Germany. It is said that this trade is in some danger owing to thousands of trees having been bled to an excessive extent.

Panama possesses considerable natural resources which are only awaiting development. Manganese has been located and mining operations begun, but no ore has, up till the present, been shipped on account of difficulties due to the nature of the country and the disastrous effects of torrential rains. Gold deposits are known to exist, and cheap labour, fuel, and water power are easily obtainable. Some attempts at gold-extraction have indeed been made in recent years, but most of them seem to have proved more or less abortive. A new company has been formed quite recently, however, and active operations are about to commence. Prospecting for oil is being vigorously pushed forward and numerous concessions have been granted by the Government.

The Panama Canal was completed in 1914, and the fact that the returns of traffic and revenue for 1924 show an appreciable increase over the previous year's figures denote that it is steadily gaining in importance as a commercial world-highway. The total number of ships using the Canal during the year ending June 30, 1924, proved greater than that of any year since the opening, and it is satisfactory to have to record that, beginning with the year 1923, the net income yielded was commensurate with the capital cost of the undertaking.

The tonnage of cargoes carried from the Pacific coast to the Atlantic coast of North America and to Europe shows a marked increase. Again, trade through the Canal between the Pacific coast of South America and the East coast of the United States and European ports is developing rapidly.

One curious feature of the traffic returns is that the percentage of cargo carried by United States and German ships increased somewhat in 1924, while the figure representing British freights showed a slight decrease. Of the total cargo-tonnage borne from ocean to ocean in 1923, United States ships carried 56·5 per cent., British Empire shipping 25·2 per cent., and German vessels 1·6 per cent. The figures for 1924 were 61·7 per cent., 22·4 per cent., and 2·7 per cent., respectively. The relative apparent decrease shown for British freights is hardly large enough to be disquieting and probably has little or no bearing on actual trade values. The fact that United States trade through the Canal is increasing is quite natural and to be expected; the figures quoted are, nevertheless, interesting, as they would seem to denote a gradual expansion in German foreign trade.

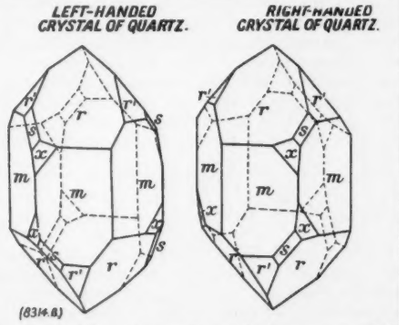
The proximity of the Canal gives to the Republic a rather spurious importance. Representatives making the transit of the Canal frequently attempt to do business at the terminal ports, where the openings are actually very restricted. A proposal, however, of some novelty is the suggestion to utilise the central position of Panama on the world's trade routes for the establishment of a commercial museum to enable buyers and sellers from all parts to examine products and get into touch with firms with whom they might do business.

In view of the suggestion made here to equip a ship as a floating fair to visit ports all over the world, Mr. Keith Jopson's comments on the visit of the "Italia" to Panama may prove of some service as showing how such an effort should not be conducted. The "Italia" apparently suffered from lack of ventilation, intense heat and bad lighting. Crowds of sightseers interfered with any attempt to do serious business, and no special hours were reserved for trade buyers. The visit is reported as not a success and few, if any, orders were placed.

NOTES.

THE PROPERTIES AND STRUCTURE OF QUARTZ.

AT the Royal Institution on January 29, Sir W. H. Bragg, F.R.S., delivered the first of a series of four lectures on the "Properties and Structure of Quartz." Quartz, said the lecturer, had many remarkable properties. It was a compound of silicon and oxygen, and it was worthy of note that oxygen formed one-half of the known crust of the earth and silicon one-quarter. The structure of quartz, so far as it could be revealed by external observation, had been very carefully studied, but the advent of X-ray analysis had supplied much fresh information, and given rise to attempts to connect the macroscopic properties



of quartz with its internal constitution as revealed by the X-rays. The problem, he said, was far from solved. In the first lecture he dealt solely with the properties of quartz as revealed by ordinary methods of examination. These showed that quartz sometimes occurred in crystals, in which an hexagonal prism was capped at each end with an hexagonal pyramid. This form, however, was far from common, a more frequent form being that represented in the accompanying diagrams, which showed, respectively, a right-handed and a left-handed crystal of quartz. Here, again, the hexagonal structure was evident, but, as it turned out, misleading, since it was found that two adjacent faces were never quite similar in texture, whilst alternate faces were. Hence, the basic structure was trigonal rather than hexagonal, and X-ray methods showed that the unit, by the repetition of which the crystal was built up, consisted of three molecules of SiO_2 arranged in a particular fashion. Right-handed and left-handed crystals were frequently combined, "twinning" being exceedingly common, and, as a consequence, many beautiful effects were produced when such crystals were examined by polarised light. This was very fully demonstrated at the lecture.

SCIENCE AND THE COTTON INDUSTRY.

When Dr. A. W. Crossley lectured at the Royal Institution ten years ago, on "Science and Industrial Problems," he mainly dwelt on pure and organised scientific research as the basis of industrial prosperity, taking his chief examples from the development of the chemical industry, the hardening of oils, and dyeing. But he also accentuated the importance of physical conditions, particularly with respect to catalysts. In his discourse on "Science and the Cotton Industry," delivered last Friday at the same Institution, Dr. Crossley, now Director of the British Cotton Industry Research Association, emphasised the services that physical research was rendering to the cotton industry and to the fascinating study of cellulose. The cotton industry, he said, had been built up on slowly accumulated experience; it was possible to spin one pound of cotton into a spider-web thread stretching 190 miles, and wonderful success had been attained in many directions; but the scientific substratum was all essential. Botany, engineering, chemistry and physics were all helping. Engineering, however, had not added any great invention to cotton machinery within the last fifty years, but the Association was modifying a machine to bring out the natural qualities of cotton rather than to produce mechanical wonders. Even mercerisation, the swelling and increase of dye-absorption power, lustre and strength, acquired by cotton when steeped in caustic soda, which was best of 15 per cent. strength, and stretched while wet after washing, was not merely a chemical process; mercerisation could be produced by physical means, and had a botanical factor because the cuticle of a hair would not stretch beyond a limit, and when this cuticle had been cut away by a micro-razor the inner cellulose bulged out. In the bleaching of cotton by means of chlorine, hypobromite, hypochlorite, or permanganate, partial oxidation had to be avoided with the utmost care; otherwise the cotton lost strength and dyed in patches. The operations were controlled by means of the cuprammonium (copper number) and the methylene-blue tests, and the determination of the hydrogen-ion concentration. The slightest trace of acidity in the bleach liquor might change the colour of indanthrene dyes. Dr. Crossley gave particulars of his studies showing the existence of at least two distinct "oxycelluloses"; to some chemists the term oxycellulose merely means that the cellulose has undergone some not clearly understood partial oxidation. Dr. Crossley further referred to the remarkable physical recording instruments for determining the regularity of yarns and of twist, and the right doubling twist that should be given to a single yarn in order to obtain the greatest lustre. Some of these machines have been noticed in our columns in connection with recent soirées of the Royal Society. Some seventy lines of cotton research, the lecturer mentioned, were now in progress.

MODERN TRAFFIC AND SIGNALLING, WITH SOME RECENT DEVELOPMENTS.

The relationship between the efficiency of the system of signalling adopted and the traffic density on a given line of rail, is one of great importance, and in a paper read by Major Edmonds before the Institute of Transport on Monday last, the author suggested that in certain cases improvement in the signalling system may offer an alternative to doubling the line. To increase the traffic density, that is, to carry more passengers or goods per day over a given length of line, either the train must be lengthened, the distance between successive trains reduced, or the average speed raised. The system of signalling has an important bearing in the two latter cases, but more particularly as regards the distance between successive trains. In this connection, Major Edmonds mentions that, by introducing automatic signals, the capacity of the District Railway was increased from 18 to 42 trains per hour. In addition to allowing an increased traffic density, automatic signalling permits of considerable working economies being effected. It is usual to combine point with signal operations in mechanical systems, and two systems are in use for the purpose—the electro-pneumatic and the all-electric. Each system has its advocates, and it does not appear that, in the present state of their development, there is much to choose between them. If an all-electric system is

adopted, it is suggested that the conditions of operation of the power supply should be different from those of the line on which the system is in use. Thus, if the system is in use on a direct-current traction line, the signalling might be alternating current, and if the traction were by alternating current, the signalling might be designed to operate with a different frequency. In this way, the signal system would be protected from leakage effects due to the main system. Major Edmonds discusses track circuits as an alternative to the older locking bars, and gives typical lay-outs for mechanically and electrically operated points. The author expresses the opinion that, given comparative conditions, a track circuit would not only equal but would probably be superior to a mechanical facing-point lock bar, both from the safety and operating points of view. One obvious advantage of the track circuit is that it can be made of any desired length without difficulty. In discussing colour light signals, a preference is expressed for a system free from mechanism in the signals, as, in this case, any relays required can be placed in the cabin or in a cast-iron relay case situated at the signal location. The majority of signalling installations in this country are at present mechanically operated, the general practice being to work the points with rodding and the signals by single wires. We described the double-wire system introduced by the Westinghouse Brake and Saxby Signal Company, Limited, in our issue of August 1, 1924, and Major Edmonds expresses the opinion that such a system compares favourably with rod-worked points and single-wire operated signals from the point of view of safety, while it involves less physical strain on the operator. It is largely used on the Continent of Europe and on the Union of South Africa Railways.

LITERATURE.

A Text-book of Petroleum Production Engineering. By Lester Charles Uren, Associate Professor of Petroleum Engineering, University of California. London: McGraw Hill Publishing Co., Limited. [Price 30*s.* net.]

Thanks largely to the efforts of the Institution of Petroleum Technologists, the petroleum technologist has for some years now been able to obtain a thorough training in his profession at two of the chief universities of this country. The department of oil mining of the University of Birmingham, under Mr. A. W. Nash, has a course of five years for theoretical and practical studies in the lecture rooms, the laboratories, in the model oil field equipped with a drilling installation, in the Easter school for geological field work, and in the summer surveying camp. Students should come well grounded in mathematics, in physics, and chemistry, lectures on which are on the syllabus for the first year; the chemical studies are continued during all the course. Similar facilities are given at the Royal School of Mines, South Kensington, under Professor W. W. Watts, where the curriculum also covers four years with a fifth year for special work. Lectures and laboratory practice for petroleum technologists are further offered at the Sir John Cass Institute, E.C., by Messrs. Ashley Carter, T. Dewhurst, and Professor J. S. S. Brame, at the Birkbeck College, and elsewhere.

The cognate institutions of the United States are older and more numerous. That none of these institutions can turn the average student, not to speak of the mere bookworm as the lazy youth with a mechanical bent, into an efficient petroleum engineer unless he has the grit in him, goes without saying. The chief in the oilfield must have a strong constitution, physically and mentally, and be a man of resource and quick decision, cautious, persevering and yet daring, and of a character to impress those under him though they may always remain his superiors in their particular work. But the college can teach him much, provide him with the proper spectacles through which to look at rocks and wells, help him to select the proper sites, machinery and tools, and tell him where to find advice and guidance. Whether the petroleum engineer can reasonably be expected to be a sound miner, engineer and electrician, and a chemist, physicist, and geologist at the same time, need not be discussed here. He certainly must be a little of all of these, and he must even have some legal knowledge in order not to involve his employers in constant litigation.

Professor Uren's text-book is compiled from this point of view. He starts with prospecting, acquisition of title, and maps and geological sections. He might have said a little more on the physical properties of petroleum, liquid and gaseous. Discussing the origin of petroleum very briefly, he expresses a preference for an organic genesis of petroleum, but he should have dealt with migration of petroleum more fully. Coming to field development and drilling he might perhaps have paid more attention in the literature references, if not in the text, to non-American experience; for instance, as regards fishing for tools. In his chapter on "churn" drilling—he does not speak of percussion drilling at all—the Fauck system is not mentioned. What he says about subsoil water can hardly be accepted in so general a form. "Everywhere the rocks are supposed to be saturated with water. The upper surface of ground water, called the "water table," is irregular in contour, but roughly parallels the earth's surface. . . . Below the water table the rocks are assumed to be saturated with water until a depth is reached at which water cannot exist." That would mean that, at a certain depth, all rocks would be under the same conditions as if enclosed with water in an autoclave at high pressure and temperature. Mr. Uren is quite aware that numerous mines are almost dry far below the water table; yet he does not seem to realise the general inferences that might be drawn from his statement, though water and steam are certainly powerful factors in the genesis of rocks.

Professor Uren further discusses transport and the preliminary refining, comprising dehydration of petroleum, but leaves the refining proper to other books. His last chapter on office methods and records would hardly have been missed if it had been omitted, though the petroleum engineer may be far removed from anybody to consult on these matters. But we readily acknowledge that the volume of 657 pages, which is based upon Professor Uren's lectures, will be a very useful book of reference to the student of petroleum engineering.

The Design and Working of Ammonia Stills. By P. Parrish, A.I.C., M.I.Chem.E. London: Ernest Benn, Limited. [Price 40*s.* net.]

Ammonia is a colourless gas, about half as heavy as air (density 0·5967), which can be condensed into a liquid boiling at −33 deg. C. and freezing to white crystals at −77 deg. C. The ammonia liquor of gas works and coke ovens contains about 2·5 grammes of ammonia per cub.-centimetre both as volatile and as fixed ammonia; the former predominates. Whether the liquid contains any free ammonia, either as NH_3 or as its hydrate, is not clear. By volatile ammonia are understood all the ammonium compounds which are volatilised, and more or less dissociated, simply by boiling; such compounds are the carbonate, sulphide, cyanide and some phenol compounds. From the fixed ammonia, comprising the sulphate, chloride, thiosulphate and thiocyanate, the ammonia has to be liberated by the addition of alkalis, generally lime, before it can be volatilised. The distillation of ammonia liquor, as originally carried out by intermittent heating in externally-fired boilers yielded only volatile ammonia. When the practice of liberating the fixed ammonia became more general, continuous distillation largely replaced intermittent working, and steam heating by means of internal coils or by direct steam was introduced.

With his volume on "The Design and Working of Ammonia Stills," Mr. Parrish, manager of the chemical works of the South Metropolitan Gas Company, has made a welcome addition to a subject, on which little has been published in book form. Most of the material hitherto published forms parts of general treatises on the alkali industry. The author attempts to give to the gas engineer what Sydney Young has given to the physical chemist by his book on Fractional Distillation. From Chapter II of Mr. Parrish's work, on the production of steam from low-grade fuel, which immediately follows the brief general survey of the subject, the reader might imagine that the book was a general manual on gas works practice. Considering that 300,000 tons of ammonium sulphate are produced annually in Great Britain by the distillation of the ammonia liquor from gas, coke-oven, blast-furnace and shale-distillation works, and that the steam wanted for the distillation represents 15 or 20 per cent. of the total cost of the ammonium sulphate, the steam consumption is a very important item, and the notes Mr. Parrish gives on it are valuable. If there had been room we should also have liked to see reference to the direct sulphate process and to the liquefaction of ammonia, the demand for liquid ammonia having much increased during the war. Mr. Parrish does not believe that superheated steam offers advantages in liquor distillation over ordinary steam, if dry.

The arrangement of the main sections is quite satisfactory. After having discussed the general problems affecting distillation and dissociation and intermittent and continuous distillation, Mr. Parrish comes to the design of ammonia stills, dealing first with their parts; next to dephlegmators, liming plants, thermal aspects, and the working and control of stills. There follow chapters on concentrated ammonia liquor and liquor ammonia; the definition of the latter term is not clear. Losses in the manufacture of concentrated ammonia are then dealt with, and treatments of waste gases and of effluents, and the use of ammonia liquor in the purification of crude coal gas. A chapter on the price of gas liquor is interposed between the carbonisation of ammonia (by carbonic acid) and the ammonia-soda process. The strength of the book lies in its practical character. Mr. Parrish points out that there is little need for seals more than 1 in. deep, and that the dimensions and numbers of gas passages should not be sufficiently great to reduce the gas velocity; he prefers bubblers to packed column stills, and does not think that the steam consumption will be lowered by adopting vacuum distillation. As regards the thermal balance, he considers that there is, in the plants of this country, a larger quantity of heat leaving the saturator than the heat interchanger between the waste gases and the gas liquor can advantageously take up. A process for crude coal-gas purification by caustic ammonia, it is interesting to find, was patented by D. Wilson, of Dublin, in 1817, but such processes have never yet been successful. Mr. Parrish proposes for the purpose a plant consisting essentially of two parts; in the one ammonia of 6·3 per cent. is to absorb the gas in scrubbers under a pressure of 30 lb. to 40 lb. per square inch, in the other the ammonium salts formed are decomposed again.

In a foreword to the volume, Dr. C. Carpenter says, that he (Dr. Carpenter) "does not mind the ruggedness of the writing nor the absence of polish in the phrasing." Neither will the reader. The comment on the ruggedness of the style need not be taken too seriously. The stout paper selected makes the book of 300 pages rather bulky. The volume is well illustrated.

The Development of the Use of the Telephone.—It is somewhat surprising that Great Britain takes such an inferior position among the nations of the world in the use of the telephone. Basing a scale on the number of instruments installed per 1,000 of the population, Britain is found to occupy the fourteenth position, and in this respect is inferior to Hawaii, Iceland, Holland and Germany. The people of the United States are the greatest telephone users and have nearly six times as many instruments for a given number of people as Great Britain. In descending order next follow, after the United States, Canada, Denmark, New Zealand, Sweden, Norway, Australia and Switzerland. The telephone service is a self-supporting one, needing no subsidies. Were the use considerably extended the value to each subscriber would be greatly increased. When the public have the advantages of this convenient adjunct to business and social life brought home to them, we have no doubt that the number of instruments installed will be greatly increased. For that reason the formation of the Telephone Development Association, is welcome. This body, from its office at Aldine House, 10-13, Bedford-street, Strand, W.C.2, intends to conduct propaganda to convince the public how great would be the benefits resulting from an increase in the number of subscribers.

THE LATE MR. C. H. WORDINGHAM.

THE death of Mr. Charles Henry Wordingham, C.B.E., makes a notable gap in the ranks of the pioneers of electricity supply in this country. Mr. Wordingham was born at Stretford near Manchester on April 14, 1866, and died, after a prolonged illness, on the 28th ult. at Redhill. He was educated at King's College School, and proceeded afterwards to King's College, where he obtained the Clothworkers' Exhibition and numerous other prizes. Whilst here he assisted Professor Grylls Adams in his experiments at the North Foreland on the relative merits of gas, oil, and electricity as lighthouse illuminants. On completing his college course in 1885 he was articled to the late Dr. John Hopkinson, for whom he carried out much experimental work in the laboratory, besides assisting him in his consulting work. Mr. Wordingham next entered the service of the United Telephone Company, and was employed by them on the erection of exchanges. In 1889 he was appointed third engineer at the Grosvenor Gallery station of the London Electric Supply Corporation, and he subsequently became head of their standardising department, for which he designed the equipment. The state of the art at the time is well indicated by the fact that when Wordingham took up his appointment there were only two or three dozen meters in use, and these but experimentally. The plan mostly in vogue was a contract rate per lamp, a system which offered great temptation to fraud. The use of meters was rapidly generalised, however, but not without protest on the part of certain large consumers, who were proved to have systematically understated their consumption of current. In a number of other cases consumers found their bills reduced to one-third of what they had previously paid. In 1892 Mr. Wordingham rejoined Hopkinson as assistant, and was in charge of the erection of the Manchester and Whitehaven central stations. The Manchester plant was of special interest as the distribution was on the Hopkinson five-wire system. This at the time offered considerable advantages as 200-volt lamps were unobtainable. Considerable difficulties were, in practice, experienced with faulty mains. The middle wire was rubber insulated, and water was forced through the pores by electric osmosis. This led to the formation of bubbles, which ultimately burst through the insulation. Mr. Wordingham ultimately got the system to work, and in 1893 came to Manchester on a temporary appointment to organise the control of the central station. It is worthy of note that the generators here were rated at 240 kw. and were regarded as "Jumbos." To-day one of ten times this output is looked upon as a small unit.

In 1894 Mr. Wordingham was offered and accepted the appointment of chief electrical engineer to the Manchester Corporation, and although he wished to retire in 1896 he was induced to hold the appointment till 1901, when he retired in order to take up consultative work. The period in question covered the craze for municipal electric tramways. The politicians, believing each others' assertions that this was the most perfect form of transport possible, and crediting on similar authority the theory that public management was more efficient than private, conceived numerous extensive schemes, which were put in hand. Manchester was no exception, and Mr. Wordingham accordingly prepared plans for high-tension electrical distribution over an area of 45 square miles. In connection with this scheme Mr. Wordingham at first contemplated distribution at 10,000 volts, but this was finally reduced to 6,600. He strongly emphasized the advantages of concentrating generating plant (probably as the result of his experiences with the London Electric Supply Corporation), and embodied this principle in his plans. At that date the steam turbine had, of course, as yet failed to convince electrical engineers of its special merits as a prime mover for central stations, and consequently the provision of ample supplies of condensing water was a less important consideration in the selection of station sites than it has since become.

As already stated, Mr. Wordingham, on relinquishing his appointment at Manchester, set up as a consultant and he had much parliamentary practice in connection with private Bills for various schemes for the supply of electricity.

In 1903 he was invited by the Admiralty to assume the direction of their electrical engineering department, and acted as their adviser for applications of electricity, both afloat or ashore. Much of the electrical equipment at both dockyards and on shipboard was out of date at the time of this appointment. The standard voltage at sea was 100, which Mr. Wordingham raised to 220, introducing at the same time the use of paper-insulated cables. Another important reform, which he succeeded in carrying through, was the calling for competitive tenders on definite specifications. He held the appointment until the Armistice, and on his retirement was awarded the C.B.E. His work during the period he held office was of great advantage to the Nation. In particular he was responsible for the electric equipment of Rosyth and of numerous naval air stations.

Photo. by the Cameograph Co., Ltd.

THE LATE MR. C. H. WORDINGHAM.

He was elected an associate member of the Institution of Civil Engineers in 1892, and was transferred to the class of member in 1899. In 1895 he became a member of the Institution of Mechanical Engineers. He was elected a member of the Institution of Electrical Engineers in 1894, and was president from 1917 to 1919. His presidential address was largely concerned with the advantages of industrial research. As chairman of the British Electrical and Allied Manufacturers Research Association he had special qualifications for discussing this subject. He also strongly advocated on the same occasion the claims of local branches. He took an active part in the work of the British Engineering Standards Association, being a member of the main committee as well as of the electrical section. He was also a member of the International Electro-Technical Committee, and of the general board and executive committee of the National Physical Laboratory. Mr. Wordingham was also one of the founders of the Electrical Development Association, and was on the Council of King's College. As showing the esteem in which he was held by other nations, it may be stated that he was honorary president of the British section of the Société des Ingénieurs Civils de France, and was appointed, by the French Government, Officier de l'Instruction Publique. Mr. Wordingham was a frequent speaker at the meetings of the Institutions of Electrical Engineers, and was the author of a valuable treatise on "Central Electric Stations."

THE LATE MR. OLIVER HEAVISIDE.

FEW men were so highly thought of by electricians of all nationalities as the late Mr. Oliver Heaviside, F.R.S., who died on Tuesday last in his seventy-fifth year, although few were able to interpret the "Electrical Papers" and "Electro-magnetic Theory" of the brilliant mathematician. Very few indeed could claim ever to have met the man whom poor health had made a recluse and who spent the last fifty years of his life in retirement in Devonshire. His contributions to the achievements of cable telegraphy and telephony, and his hypothesis of the Heaviside layer of the atmosphere, by the aid of which radio-telegraphic waves travel round the world, are known to everybody. But most students, content that the solution of a problem was "somewhere in Heaviside," studied him indirectly. We have to defer to a subsequent issue further reference to his life and work.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—The annual dinner of the above Institution will take place on Friday, February 20, at 7 p.m., at the Engineers' Club, Coventry-street, W.1.

FARADAY MEDAL.—The Council of the Institution of Electrical Engineers have made the fourth award of the Faraday Medal to Sir J. J. Thomson, M.A., O.M., F.R.S., an honorary Member of the Institution, and Master of Trinity College, Cambridge. The Faraday Medal is awarded by the council of the Institution, not more frequently than once a year, either for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership of the Institution.

WEEKLY IRON AND STEEL REPORT.—Steady conditions rule in the iron and steel markets according to the report of The London Iron and Steel Exchange, Limited, for the week ended February 3. There are indications of a gradually improving demand. The attitude of the Continental manufacturers remains firm as regards price, and they are able to maintain this position largely as the result of orders for steel material emanating from Germany. The Belgian works in particular have benefited by a large business in steel rails. In the pig-iron section there has been some enquiry from the United States for British material. The business transacted in the finished steel department has been of small dimensions.

THE INSTITUTE OF METALS.—It is announced that the annual general meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W. 1, on March 11 and 12, the proceedings commencing each day at 10 a.m. The annual dinner will take place at the Trocadero Restaurant on Wednesday, March 11, at 7 p.m., and those who intend to be present should apply for tickets to the Secretary, at 14, Members Mansions, S.W. 1. We note that the thirty-second volume of the Journal of the Institute has now been published. Thirteen communications presented at the autumn meeting, the May lecture, and the Seventh Report to the Corrosion Research Committee are included in the work, together with other useful matter.

INSTITUTION OF CIVIL ENGINEERS.— A meeting of the Birmingham and District Association of the Institution of Civil Engineers was held on January 26, with Mr. J. E. Willcox, the President, in the chair, when Mr. H. E. Stilgoe, Chief Engineer to the Metropolitan Water Board, delivered a lecture of "Some Features of the London Water Supply." In the course of his remarks, Mr. Stilgoe stated that the area of the Metropolitan Water Board was about 558 square miles, and the total population supplied just over 7,000,000. The quantity of water provided for the year ended March 31, 1924, amounted to 91,839·8 million gallons, a daily average of 250·83 million gallons. The water supply of London, apart from the magnitude of the undertaking, afforded particular problems, and unlike a town supplied by gravitation—by means of reservoirs and filter beds situated at commanding altitudes—the whole of London's water had to be pumped, sometimes in as many as four operations. Water was first forced under pressure from the river intakes to the storage reservoirs. After filtration it was driven into the supply stream by different stages, according to the altitude of the localities served. In many cases it was pumped literally into supply, as the large trunk mains *en route* to the service reservoirs also supplied larger distributing mains. The pumping engines were, for the most part, steam driven, and about 180,000 tons of coal were consumed in the boilers annually. Diesel oil engines were used at four pumping stations. The lecturer stated that, as a general principle, steam pumping engines were to be preferred where they ran, as did many of the board's engines, for 80 per cent. to 90 per cent. of the entire year. The oil engines, however, were convenient and economical as a standby. The new works at the Littleton Reservoir were described, together with the sand and mechanical filtration and chlorinating plants there. A number of lantern slides showing works under construction were exhibited.

THE DEVELOPMENT OF WATER-POWER, WITH SPECIAL REFERENCE TO INDIA.*

By BERTRAM DARELL RICHARDS, B.Sc., M.Inst.C.E.

THE great advances made during recent years in electrical engineering, and particularly in high-tension transmission, have given a great impetus to water-power development, which has been further stimulated by the growth of electro-chemical and electro-thermal industries. On the subject of the cost of water-power it appears to be impossible to generalise; the true measure of the value of a water-power site is the rate at which power can be delivered from it to a market, as compared with that of power from any other source available.

A common classification of water-power schemes is by head, schemes being classified as high-head, low-head, or intermediate. The author suggests that perhaps a more useful classification would be on the basis of storage-provision, schemes being divided into storage, non-storage, and partial-storage schemes. He proceeds to show that under general conditions, the two classifications are more or less parallel, it being, generally speaking, not economical to provide any considerable storage-capacity where a fairly large head is not available. The conditions of rainfall obtaining in India are such that most water-power schemes of any magnitude come under the classification of storage or partial-storage schemes. The combination of power and irrigation is discussed. A power scheme lends itself better to adaptation to irrigation than does an irrigation scheme to power, as power-supply is generally continuous throughout the year, while irrigation is discontinuous and often intermittent.

A prominent consideration in Indian schemes is the question of balancing storage, and how much storage to provide for the most economical development of the catchment-area. This depends on: (1) variations in the yield of the catchment-area, (2) possibilities and cost of storage, (3) range of variation permissible in the power-supply, (4) limiting rate for the sale of power.

Variations in yield are both seasonal and annual; the annual variation is often very great, and figures are quoted for various catchments investigated. The possible variations in power-supply will depend on the nature of the uses to which the power is to be applied, and such variations may be seasonal, annual, or a combination of both. The rate for the sale of power will also depend on its use. The problem is to ascertain to what extent the variations in yield can be economically balanced to give a power-supply subject to variations within the limits prescribed. There are two variable factors: the quantity of power and the volume of storage; the limit of the former is that the average power is that corresponding to the average yield of the catchment-area; the limit of the latter is set by the possibilities of the site. The final governing factor is the cost at which the power can be produced.

Consideration of these points leads to the following conclusions: (1) The higher the available head, the greater will be the degree of balancing economically possible. (2) The higher the market rate for power, the greater the degree of balancing possible. (3) The greater the permissible variations in power-supply, the cheaper will be the power. (This, however, is subject to qualification in regard to load-factor.)

The purposes to which power is applied may be divided into two main classes, namely: (1) general industrial purposes, and (2) electro-chemical industries. The load-factor of each class is discussed. Loads of the second class lend themselves to variations, within limits, of the power; and as they also carry a high load-factor, the selling rate for power to these industries can be low; but, on the other hand, loads of the first class will carry a much higher rate.

The provision for an occasional year of abnormally low rainfall is discussed, and the question is considered whether, in certain circumstances, it is necessary to make such provision. Under favourable conditions, balancing can be carried to a very high degree, and relevant figures are quoted from the Tata hydro-electric scheme.

The question of the provision of balancing storage has been considered from the point of view of the development of a catchment-area to its fullest possible extent. It may happen that the immediate power requirements do not necessitate this. In designing a scheme, however, it is desirable to provide for future extension where possible, and in partly developing a catchment-area to keep in view its subsequent complete development. There is another aspect of this: A country's water-power resources are a national asset, and where the State assumes any control over them, it would be unlikely to permit any partial development of a favourable site which would interfere with subsequent further development.

The problems of balancing storage are conveniently treated graphically. Diagrams are given, based on the investigations of an actual catchment-area. The first condition assumed is that of constant annual load. A typical balance diagram is shown for a certain condition of load and storage. Curves are given connecting net storage with gross annual draw-off, net storage with net annual draw-off, net storage with full-supply level of lake, net draw-off with power, and power with full-supply level of lake.

The next condition is that of seasonal variation of the load. In the case taken, the draw-off for half the year is 40 per cent. in excess of that for the other half. Comparative curves are given showing the effect and value of the introduction of this variation.

The third condition assumed is that of annual variation of the load. An annual variation to correspond, to some extent, with the annual variation of the yield cannot be definitely fixed as in the previous case, nor can the yield of any year be forecast to determine the available draw-off. Some working basis must be arranged, and the following is suggested: The draw-off in any year to equal the yield of the preceding year (where such yield is less than the maximum that can be accommodated by the plant capacity). In this case, if the yield of the current year were in excess of that of the preceding, water would be available for storing; if the reverse, the storage-reserve would be drawn on. This arrangement should be accompanied by the proviso that the minimum draw-off should be a certain percentage of the plant-capacity. This arrangement provides a definite working basis; the draw-off in any year is never less than a certain quantity, and the actual power available for any year is known at the beginning of the year. The case taken is for the minimum factor at 60 per cent., and curves are given showing the effect and value of the annual variation.

A study of the whole series of curves leads to the following conclusions:—(1) In the case of a catchment-area with large seasonal and annual variations of yield, the seasonal variations are easier to balance than the annual. (2) For constant power, the available power is increased greatly by the provision of storage up to the point where the storage is sufficient to balance the seasonal variation of yield of the minimum year; after that the increment of power for each increment of storage decreases until it becomes no longer economical to provide further storage. (3) Under favourable conditions, a high degree of balancing may be economically attained with conditions of constant power, and in such cases the introduction of definite variations in the power will not greatly increase the total power available. (4) In a case where a site does not offer possibilities of large storage, or where such conditions as low head render the provision of large storage economically impossible, the introduction of seasonal or annual variations in the load will enable a far greater quantity of power to be taken from a catchment area.

The determination of the yield of a catchment area is considered. Direct and indirect methods of estimating the yield for any year, and the application of the available data to estimate the yield for a sufficient period of years to meet the annual variations of rainfall, are discussed.

The recorded data of yield-factors for Indian catchments are few; and the experimental determination of the factor for a catchment area is a somewhat complicated matter. It would be of great value to the profession if engineers in India were to publish any results they obtain, accompanied by a general description of the catchment area and notes as to the incidence of the rainfall.

The present state of Indian water-power development is briefly referred to. India possesses large potential supplies of water-power at rates which compare favourably with those obtaining elsewhere. With her vast supplies of raw materials and her teeming population, she has great industrial opportunities, in the realisation of which her water-power resources should play a leading part.

* Abstract of a paper to be read before the Institution of Civil Engineers, on Tuesday, February 10, 1925.

SMOKE-ABATEMENT EXHIBITION.—Fogs are engaging the attention of the research departments of a number of manufacturing firms at present. Investigations are being conducted in two main directions. One branch deals with the discovery of more effective means of securing smoke abatement; the other with devising new appliances and apparatus for minimising the economic effects of fog. It has been arranged that the practical results of this organised study and experiment shall be demonstrated to the public at a special international smoke-abatement exhibition to be held in the autumn of next year at Bingley Hall, Birmingham, under the auspices of the Smoke Abatement League of Great Britain. A representative committee of experts is now in course of formation. It has also been decided that during the exhibition, a series of important conferences shall take place, covering every aspect of smoke abatement and remedial measures in periods of fog. The headquarters of the Smoke Abatement League are at Manchester.

LABOUR NOTES.

So much has been written and spoken within the last few weeks on the subject of the new national all-grades programme of the National Union of Railwaymen that there did not seem to be another side to the highly important question involved. At Tuesday's meeting of the railway managers and representatives of the National Union of Railwaymen and the Railway Clerks' Association, the fact that there was another side was, however, duly emphasised. Mr. Cramp and his associates put forward the men's programme and explained its principles. The representatives of the companies not only definitely declined to concede the claims, but also submitted counter-proposals to the effect that the wages of certain classes of workers should be reduced. They claimed that in the case of employees belonging to conciliation grades or working under conciliation conditions, there should be immediate flat-rate reductions in base and current rates of 6*s.* per week in rural areas, and 4*s.* per week in London and industrial areas, the existing cost-of-living sliding scale arrangement being retained. In the case of salaried, clerical and supervisory staff, no alteration was proposed to be made in the scales of pay, except that the adult age for clerical staff (male and female) should be raised from 18 to 20, and that junior male clerks should not be advanced to the Class 5 scale until there was a Class 5 vacancy and they had passed the appropriate examinations.

According to an official statement issued on Tuesday by the companies, the general managers informed the trade unions that the companies could not agree to an increase in present rates of pay, or an improvement in conditions of service involving increased costs. On the contrary, the railway companies had come to the conclusion, it was stated, that, in existing circumstances, they had no alternative but to press for a reduction of the present labour costs of the railways.

On the available facts, the railway services of the country clearly cannot bear the additions to their costs which the men's programme involve. Before the war the total wage bill of the railway companies amounted to 47,000,000*l.* per annum. At the present time the railway wage bill, including the wages of the additional staff employed as a result of the reduction of hours granted during the period of Government control, is at the rate of 120,000,000*l.* per annum, or two and a-half times the pre-war total, an increase of 155 per cent. The average rate of pay of railwaymen is approximately 115 per cent. over pre-war. The average increase applicable to all industries is from 70 per cent. to 75 per cent. The programme which has been submitted by the trade unions is estimated to cost a further 45,000,000*l.* per annum. If these demands were granted, it would bring the increase in the railway wage bill up to 250 per cent. above pre-war.

The leaders of the railwaymen were naturally disappointed with the result of the meeting. Mr. Cramp pointed out, however, that machinery exists for a full discussion of the points at issue, so far as the conciliation grades were concerned, and that it would probably be utilised. On Wednesday the executive of the Railway Clerks' Association decided to refer their claims to the Central Wages Board.

For a time during the week it looked as if serious trouble were inevitable at a power station of one of London's principal tube railways. On behalf of 30 of its members, employed as fitters and electricians at the Metropolitan Railway Company's Neasden power station, the Electrical Trades Union demanded a certain readjustment of wage rates. The railway company declined to accede, but offered to refer the question to the Industrial Court or to arbitration. The union would have nothing to do with either the Industrial Court or arbitration, and threatened to withdraw the whole of its members employed at Neasden, about 300 men in all, on Wednesday, if the company did not give way. The Ministry of Labour, in consultation with representatives of both parties, endeavoured to find a way out of the difficulty, and early on Tuesday evening provisional terms of settlement were agreed to, which were afterwards endorsed by a mass meeting of the men. These terms gave an immediate increase in wages, ranging from 6*s.* per week to 1*s.* per week, and promised further consideration to outstanding differences.

One, at any rate, of the Labour Movement's prominent men is alive to the danger of Communism's "permeation" of British Trade Unionism. Speaking at Mitcham this week, Mr. J. R. Clynes said that British Trade Unionism was now required to make a stand against those whose first task was that of creating distraction and confusion within the unions, and who by fostering divisions among the rank and file, hoped for complete disruption. Their energies were spent in waving revolution banners and in the worship of the names of Russian leaders. Other countries had nothing to teach the British people with respect to industrial organisation and successful political endeavour. They must therefore emphatically resist the efforts being made to form minority movements within the trade union ranks. It was fooling with working-class unity to create divisions among members, detaching delegates and groups of workmen from the main body, and then calling conferences to demand a united front against organised capitalists. "This method gives joy," Mr. Clynes declared, "to our enemies in the degree that it weakens and impairs the trade union movement."

The meeting between the executives of the Mining Association and the Miners' Federation was, it is understood, friendly enough, but disappointing in its definite results. Speaking for the coalowners, Mr. Evan Williams pointed out that owing to the high cost of production, this country was losing markets to Germany and other Continental countries where the hours worked were longer and the output greater. He suggested that the economic position was so serious for all in the industry, that it would be well, he thought, to appoint a Sub-committee, representing both sides, thoroughly to investigate the matter and report to a further meeting of the parties. Mr. Herbert Smith said that the executive of the Miners' Federation could not accept the invitation to appoint members to serve on a joint committee, but they were quite willing to meet the coalowners at any time, to hear and consider any proposals which they might make for the improvement of the industry. The Miners' Federation would not, however, discuss or consider any extension of the present seven-hour day, or any revision of the existing minimum wage rates. Mr. Evan Williams expressed disappointment at the attitude of the Miners' Federation.

The National Allied Building Trades Employers have passed the following resolution :—

"This meeting of National Allied Building Trades Employers having considered the situation created by the avowed intention of certain organisations to secede from the National Wages and Conditions Council and also from the National Federation of Building Trades Operatives, thinks it advisable to make clear to all concerned what the attitude of the National Allied Building Trades Employers is towards the National Wages and Conditions Council and the national settlement of wages and conditions carried on under the constitution of that body, and therefore resolves :—

(*a*) That the principles of the constitution of the National Wages and Conditions Council afford a basis for national negotiation capable of adjustment and amendment to meet changing conditions, and should therefore continue as the appropriate means for effecting the negotiations of wages and conditions for the building industry. That the National Allied Building Trades Employers will resist to the utmost of its power any action having for its object the substitution of sectional methods of negotiations either nationally, regionally, or locally for the national industrial method of negotiation at present in force.

(*b*) That in view of the engagements into which the National Federation of Building Trades Operatives entered on August 22, 1924, on behalf of its then adherent bodies, the National Allied Building Trades Employers requires all those bodies to honour and fulfil those engagements in every particular."

A national conference of members of the National Joint Industrial Council for Local Authorities Non-Trading Services (Manual Workers), representatives from the areas of certain of the Provincial Councils which have ceased to act, and others, was held last week at the Ministry of Labour. After considerable discussion, the following resolution was adopted :—"That the machinery of Whitleyism deserves to be extended and perfected, and that measures be taken at once to secure greater cohesion and agreement between the constituent bodies of the National and the Provincial Councils respectively."

The West Midland Provincial Council (Workers' Side) submitted a motion that it should be regarded as a *sine qua non* of Whitleyism that all workpeople should be members of an appropriate trade union, and that the employers' side of Non-Trading Joint Industrial Councils should take steps to secure that.

Mr. A. Taylor (general secretary of the National Union of Corporation Workers) strongly opposed the resolution as a Trade Unionist. It was, he declared, a wicked resolution, and would have a bad effect if acted on. Men would be penalised because they did not happen to belong to some particular union and not on the broad ground that they were non-unionists. He was in favour of working men joining their trade unions, but he wanted a little fair play.

Opposition to the proposal also came from the employers' side, and it was pointed out that the trade unions could achieve the result aimed at by methods of persuasion without resorting to compulsion. The proposal was not appproved.

The *Times* correspondent at Cape Town states that the South African Government have introduced a Bill to establish the principle of a legal minimum wage in all industries. Under its provisions a Central Wages Board, consisting of three members appointed by the Minister, is to be set up with the duty of recommending a minimum wage in each industry by districts. In each industry the men and masters will respectively appoint two assessors in order to assist the Board. The Board will make its recommendations to the Minister, who will then fix the minimum wage, but he is not compelled to accept the Board's findings unaltered. When the wages have been fixed by the Minister, either the masters or the men in any industry will be entitled to object, and, in that case, the Minister is compelled to appoint an arbitrator, who will examine the position anew and report to the Minister. The Minister will then give his decision, which will be final. The Bill thus seeks to combine, the correspondent adds, the English Wages Boards system with the Australian arbitration system.

One or two of the shipbuilding industry's trade unions have still, it is understood, to be heard by the Shipbuilding Employers Federation in support of demands for increases of wages; but, judging from what took place at last Friday's conference in London between the employers and several of the other groups, the need to hold meetings for the purpose of discussing the applications is not very clear. The representatives of the Federated Trades and the Boilermakers Society were told by the employers that the state of the industry did not permit of any further addition to its labour costs. There is, it will be agreed, no doubt about that. According to Lloyd's Register's latest quarterly shipbuilding returns, more tonnage is being launched than is being laid down, and work on the stocks is steadily diminishing. Of the total number of available berths only about 30 per cent. are now occupied. In ship repairing, the decline of activity is just as marked. The number of "dock" days on which dry docks were unoccupied during a recent quarter was 20 per cent. greater than in a similar period before the June wages award of the Industrial Court came into operation. These facts are, moreover, confirmed by the unemployment figure which is 32 per cent. for the whole industry, and much higher for the ironworkers.

Far from justifying an advance of wages, the state of the industry would warrant a decrease, for high labour costs are clearly not only keeping our shipbuilders out of foreign markets, but are also preventing our shipowners from ordering the new vessels which many of them need for the maintenance of their services. Lower labour costs are essential to a revival of British shipbuilding, and it is no doubt knowledge of that which has induced the employers to offer to discuss with the representatives of their workpeople proposals for the regulation of wages by machinery, providing for an ascertainment and sharing of the proceeds of the industry on a reasonable and fair basis. Mutual arrangements on these lines are, of course, unpopular with Labour's extremists, but if British shipbuilding is ever again to operate on a profitable scale something of the kind is clearly necessary.

The Ministry of Labour states that on January 26, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,241,000, namely 935,500 men, 37,800 boys, 231,700 women, and 36,000 girls. On January 19, 1925, the number was 1,269,733, 959,684 being men, 39,517 boys, 234,561 women, and 35,971 girls. On January 28, 1924, it was 1,320,518. Of these 982,083 were men, 43,550 boys, 254,026 women, and 40,859 girls.

The employees of the Office of Works who went on strike last week in order to enforce a demand for the dismissal of a fellow worker whose membership of the Electrical Trade Union had lapsed returned to work on Tuesday. From beginning to end of the trouble, the Office of Works very properly declined to discriminate between unionists and non-unionists and refused to dispense with the services of the man objected to. The six unions involved were, therefore, obliged to seek a solution of the difficulty in another direction, and eventually they found one by taking an undertaking from the worker concerned to pay his arrears by instalments and in that way reinstate himself as a member of the Union. The trouble could have been ended on these lines before an hour had been lost, as the man was all along willing to pay the arrears, provided he were given time to do so. The strike may, therefore, be written down a failure—a fate which all

movements of the kind deserve. Whether a worker is, or is not, a member of a trade union is not a concern of the employer's. If a union cannot get and keep the great majority of the workers in the trade for which it caters, its attractiveness as an efficient organisation is clearly to blame, and employers ought not to be coerced by stoppages, or threats of stoppages, of their businesses, to make good the defect.

Factory Groups, constituted on communist lines after the Russian model, are being formed in the principal industrial areas of Great Britain. In the middle of last month, according to the *Workers' Weekly*, seven were in existence in the Bradford district and two more were being organised. The average membership is three. Five of the groups are in collieries, two in metal works, one in a clothing factory and one in an industry which is not indicated.

Personal.—Mr. David Low, general manager of the Stannergate shipyard of the Caledon Shipbuilding and Engineering Company, Limited, Dundee, has been appointed shipyard manager of the Dalmuir yards of Messrs. William Beardmore and Co., Limited, under Mr. A. J. Campbell, the general manager of the entire works. Mr. Low, besides being connected with two Dundee concerns, has also had extensive experience in yards on the Clyde and Tyne.—The D.P. Battery Company, Limited, of Bakewell, Derbyshire, have appointed Messrs. Kelsall and Parsons, of 19, Blythwood-square, Glasgow, to be their agents in Scotland.—Mr. John F. Avila has now joined the firm of Messrs. John Sterling and Co., consulting engineers, of 66, Victoria-street, London, S.W. 1.

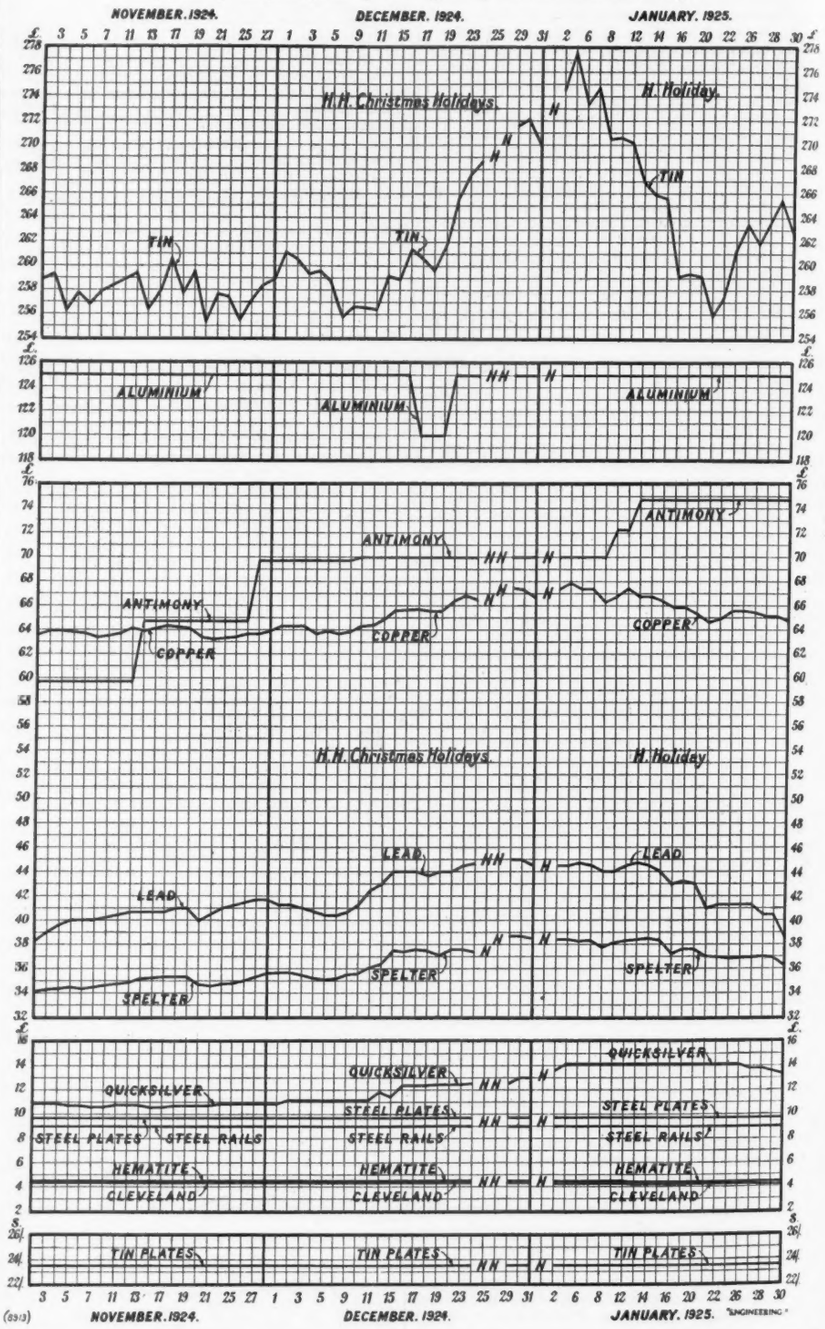
The Aluminium Alloy Alpax.—In our issue of January 9, page 46, we published an article discussing the characteristics of the new aluminium alloy Alpax. The name of this alloy is derived from that of the inventor, Dr. Alardar Pacz, and the alloy is handled in this country by Messrs. Lightalloys, Limited, St. Leonards-road, Willesden Junction, London, N.W.10, who, we understand, are adopting this material for a large variety of work. In motor work the alloy has been found particularly suitable for cylinder blocks, heads, pistons, crankcases, differential casings, &c. Complete bodies can be built of it, and it is being used in railway carriage work in various ways. Owing to its resistance to corrosion, it is suitable for use in connection with many types of chemical plant, and for marine and other unfavourable conditions.

Testing Galvanised Iron: Addendum.—In an article by Mr. Sherard Cowper-Coles on "Methods of Testing Galvanised Iron," which we published in our issue of December 19 last, on page 825, reference was made to the copper-sulphate test which is also known as Preece's test. The test, it was stated, although still extensively used, is very unreliable, depending considerably upon the method of manipulation. This opinion is confirmed by Mr. W. M. Pierce, of the Research Division of the New Jersey Zinc Corporation, Palmerton, Pa., U.S.A., who has called our attention to an article by him, published in *The Iron Age* of July 24, 1924, to which reference may be made by those interested in the subject. Among the conclusions derived from the experimental work referred to in the article are the following:—The Preece test cannot possibly serve as a test for the weight of the coating, though it may be of value in indicating the uniformity of the coating; and unless a fixed relation can be shown to exist between the results of the Preece test and life under atmospheric exposure, the stripping and weighing test must be regarded as the most reliable indication of the quality of zinc coatings.

Contracts.—The John Thompson Water Tube Boilers Company, Limited, of Imperial House, Kingsway, London, W.C.2, have secured a repeat order from the Falkirk Electricity Works for a patent vertical straight tube boiler having 5,000 sq. ft. of heating surface and working at a pressure of 200 lb. per square inch.—Messrs. Sir William Arrol and Co., Limited, of Glasgow, have secured an order from the Sudan Government for four large bridge transporters, fitted with grabs of 2 tons capacity. These are required in connection with extensions to be undertaken at Port Sudan.—The Westinghouse Brake and Saxby Signal Company, Limited, have secured a contract for the supply and installation of a large electro-pneumatic signalling outfit for use at the Temperley Junction of the Buenos Aires Great Southern Railway.—The Vickers Spearing Boiler Company, Limited, of 20, Kingsway, London, W.C.2, have secured the contract for the complete boiler-house equipment of the new generating station for the Municipality of Bloemfontein. The plant will consist of four water-tube boilers of the two drum cross-type, each with a maximum evaporation of 37,000 lb. per hour at a working pressure of 265 lbs. per square inch, with superheaters to give a final steam temperature of 600 deg. F. Upon each boiler there will be superposed an economiser, with horizontal tubes, suitable for dealing with feed water having a temperature of 120 deg. F. The boilers will have chain grate stokers of the Illinois compartment type, and flat suspended arches. They will work under balanced draught conditions and the necessary equipment for this, as well as feed and service pump, de-aerators, water-softening plant, evaporators and steel chimneys, are included in the contract.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

The Lyons Fair.—It is announced that arrangements have been completed with Messrs. Thos. Cook and Son, the official travel agents of the Lyons Fair, to be held in France during March 2–15, for parties of visitors from this country to attend the Fair at an inclusive charge of 13*l.* per person, which covers first-class travelling and hotel expenses. Those desiring to avail themselves of these facilities are requested to write to The Official British Representative of the Lyons Fair, at 77A, Queen Victoria-street, London, E.C. 4, enclosing a registration fee of one guinea, which will be deducted from the amount of the fare.

NOTES ON NEW BOOKS.

PERHAPS two of the most important matters which concern our modern civilisation are the economical generation of electrical energy and cheap transport. These two things are of such fundamental importance that it can be said that our material welfare is very largely dependent upon the progress and development made in these problems. "*Railway Electrification*," by H. F. Trewman, M.A., A.M.I.E.E. (London: Sir Isaac Pitman and Sons, Limited; price 25*s.* net), deals with the transport problem, and is a complete survey of the economics of the different systems of railway electrification from both the engineering and financial points of view. The whole book is planned in such a logical and systematic manner that it is a real pleasure to read it. The first section deals with the generation of electrical energy, examples of modern power stations being briefly described, their cost per kilowatt of suitable plant and the cost per unit of energy being given. The transmission of the electricity to the sub-stations is then dealt with, comparative costs of medium and high-pressure systems for both overhead and underground transmission being worked out. The succeeding sections are devoted to the conversion in sub-stations and distribution of the energy to the trains the various types of electric-traction motors employed, both alternating-current and direct-current types being described, and their relative costs given. There are also chapters on the energy required to operate the trains, the weight of the equipment necessary, suburban electric trains, and considerations of trunk-line service. The author arrives at the conclusion that from a financial point of view the electrification of suburban lines employing a direct-current system, is almost an assured success, and that experience shows that electrification within a radius of, say, 25 miles of a large town will at once induce a steadily increasing passenger traffic, particularly where the suburban population is rapidly increasing, as is the case in and around London. Electrification of main-line railways, however, does not present anything like such a favourable proposition; and there does not appear to be the possibility of earning sufficient extra profit to justify the required capital expenditure. Altogether, we can recommend the book as one which may be read with interest and profit by all those interested in the subject.

Mr. J. Czochralski need not regret his inability to cover completely the whole system of metallography in his "*Moderne Metallkunde in Theorie und Praxis*," (Berlin: Julius Springer; price 2·85 dol.). Not many years ago the term "Metallkunde" might indeed have been considered equivalent to "metallurgy." With the recognition of the direct practical importance of the structures of metals and their modifications by physical and chemical influences, the study of metallography itself has grown into so large a subject that a volume of 292 pages would have to limit itself to certain branches of this type of research. Keeping on general grounds, Mr. Czochralski has certainly written an instructive book on certain aspects of metallography. He does not especially refer to steels nor to any particular alloys, nor to corrosion. His main sections deal with metal structure and the phase rule, equilibrium diagrams, recrystallisation, thermal treatment, and the strength of metals under the two general headings of cast metals and of worked metals. A good many of his 298 excellent illustrations and text-figures are novel, and he has his own suggestive way of presenting the problems. His Röntgen-ray studies of stress-strain phenomena, noticed in our issues of December 14 and 21, 1923, have been extended in other directions. As regards flow phenomena he considers that the unit cell is actually distorted by a regrouping of the atoms in the cell; he does not believe that the slip planes coincide with the crystallographic planes, the latter being rather planes of maximum shear resistance. He points out in this connection that the Brinell ball impression sometimes appear square, and that the sclerometer test is really of the nature of a Brinell test. His illustrations of twisted single crystals, of over-strained brass rods which have cracked and been distorted into curious shapes resembling tree trunks with short jagged-ended branches, and of the structures of extruded and punched materials, are very interesting.

It is popularly supposed that the finish and durability of modern coach-painting compares unfavourably with the results obtained a decade ago, but an unbiassed examination of such an exhibition of the coach-painter's art as the recent motor show at Olympia indicates that such a view is hardly supported by facts. While it is true that it would be almost impossible to improve on the work of the earlier craftsmen, the high standard which they set has been fully maintained, and, concurrently the time occupied on the work has been cut down very considerably. Up to a few years ago it was recognised that a really high-class finish could not be obtained under three weeks, but at the present time excellent work is being turned out in as many days. This economy in the time occupied has resulted mainly from the superior finish of the modern pressed panel, which leaves the machine in such a condition that little or no filling is necessary, and thus one of the longest processes in the subsequent painting operation is practically eliminated. At the same time, the various firms engaged in the oil and colour industries have been successful in developing materials which dry more rapidly, and, finally, the enormous increase in the output of cars by individual firms has enabled them to equip their works in such a manner as to take full advantage of the new materials. In "*Modern Car and Coach Painting*" (London: W. R. Howell and Co., 28*s.* 6*d.* net) Mr. C. E. Oliver describes modern methods in considerable detail, ranging from the repainting of a single car to the processes involved in obtaining an output of several hundred cars per week. In the first portion of the book a description is given of the ordinary methods employed when hand work is resorted to exclusively, and every process is described minutely and illustrated in such a way that nothing is left to the imagination of the operator. Subsidiary processes, such as lining, applying transfers, brush-graining, and lettering are described in similar detail, and this portion of the book should chiefly be of value to the shop foreman or actual operator who is anxious to obtain the best possible results by hand methods. In the case of the larger firms spraying and dipping have largely superseded hand painting, and to ensure a regular and even output the most careful attention has been devoted to the design and equipment of the paint shops. In such cases an output of high-grade work of uniform quality is more a question of works organisation than individual skill, and officials whose duties include the erection of suitable shops or their subsequent supervision will find much of value in the later part of Mr. Oliver's book. The necessary equipment naturally depends on the output, but in every case drying-rooms are essential in which the air is cleaned of impurities, warmed to the correct temperature, humidified to the right degree, and kept in constant circulation. The necessary equipments for outputs varying from 150 to 600 cars per week are dealt with by the author, plans of the various shops being given, and the order of and time required for each process being described. A chapter which should prove of particular value is that devoted to the testing of materials used in car painting, as it is upon a correct choice of the materials employed that the success of the whole of the operations ultimately depends. The work concludes with chapters on the commercial aspect of the subject.

At the end of the past century it was generally believed, largely on the basis of the work of Hennebique and the researches of Considère, that the strength of concrete could much be increased by its reinforcement with iron. If a concrete beam would bear stretching to 1 : 10,000, reinforcement was considered as capable of raising that ratio to ten and even twenty times its value. Later on, those assumptions were altogether questioned, notably by Bach, who suggested that concrete under stress would be converted into a system of "cores" able to resist compression, but unable to take up tensile stress, so that the iron bars in the concrete beam would delay, but not prevent, its destruction under excessive stress. Bach placed the admissible tensile stress at 750 kg. per square centimetre (4·8 tons per square inch); that figure was officially adopted in Germany for railway bridges, but was gradually exceeded. The prevalent practical view is probably that the reinforcement takes up the tensile stress, and the concrete the compression stress. Examining the recent investigations of French and German workers, especially of Probet and Schüle in a monograph on "*Die Arbeitsfestigkeit der Eisenbetonbalken*" [Berlin: Julius Springer, price 0·55 dollar], Mr. Wilhelm Thiel, a Berlin engineer, proposes a compromise between the views of Considère and Bach. He also suggests a hypothesis, admittedly incomplete, for the strength of concrete based upon the modern conception of space lattices. The book is a study; he does not adduce any new experimental data, and he is not acquainted with the recent work done in England, especially at the National Physical Laboratory, official reports of which have not yet been published.

Very detailed particulars on the railway tracks and gauges of the world are contained in three books by Mr. Léon Wiener, Director of the Compagnie Belge de Chemins de Fer et d'Entreprises, 33, Rue de l'Industrie, Brussels. One of these, entitled "*Les Ecartements des Voies de Chemins de Fer*," is a reprint from the proceedings of the International Railway Congress. It is in three sections, the first of which deals with the question of railway gauges in the different countries from a general standpoint, and with the relation existing between the gauge, the rolling-stock and the working of the lines; the second section deals with transhipment between lines of different gauges and describes the arrangements used for this purpose on the railways of various countries; the third describes railway reconstruction and gauge unification in European countries and countries overseas. The second book, "*Rendement et Possibilités des divers Ecartements de Chemins de Fer*," is issued by the Société Belge des Ingénieurs et des Industrials, and reviews each gauge in succession, namely, the broad, normal, 3 ft. 6 in., metre, 3 ft., 2 ft. 6 in. and 2 ft. gauges, and gives very complete particulars on the characteristic features and dimensions of the locomotives and rolling-stock appertaining to each gauge. The economics of each gauge are also entered into. The third book, a reprint from the proceedings of the Fédération des Constructeurs de Belgique, is entitled "*Renseignements sur les Ecartements des Voies de Chemins de Fer de tous Pays*"; it deals with the railway gauges by countries and thus forms a useful complement to the two other publications. The colonies are classified under the name of the mother country. The three books together form a very complete and interesting encyclopedia on the railways of every nation, and will prove of great value for reference purposes, especially to engineers and others engaged upon problems involving decision as to the best gauge for certain circumstances, or as to the advantages to be gained from conversion or unification. The author has carried out his task in a most painstaking and exhaustive manner.

Mr. Martin Boerner's "*Draht-Welt-Buch*" is much better than the title, "Wire-World Book," and the preface, which begins with "Dear reader," would lead one to anticipate. It is obviously compiled by practical men, but their names are not given; there are no references, and there is no index to inform us that, for instance, tungsten wires are noticed. The list of contents is detailed, and there are many very useful tables and illustrations. Yet the whole, though technical throughout, is written too much like a novel to justify its claim to be: "A text-book and reference volume for the whole wire industry." The chief wire materials dealt with are mild steel, steel and copper; other metals are discussed and there are special chapters on welded chains, texture of the drawn metal, and also on temperature measurements—a rather unexpected section. The volume of 355 pages is published by the Draht-Welt-Verlag, Martin Boerner, of Halle-on-the-Saale; a price is not stated.

That the world would be healthier and richer if all the rats were exterminated will be readily conceded, and the advice of an expert who is prepared to submit an organised scheme for the reduction of their numbers should receive attention. Mr. Mark Hovell, F.R.C.S., is recommended as one who has specialised in rat destruction, and has applied his methods with success. We, therefore, read his book, "*Rats and How to Destroy Them*" (Bale, Sons and Danielsson, Limited, London, price 10*s.* 6*d.* net), with considerable interest, and we hope that his recommendations may prove of value. The loss suffered through the depredation of rats is large, and in the aggregate constitutes a heavy national tax, the amount suggested here is no less than 52,000,000*l.* However difficult it may be to credit such a large estimate, we certainly give a ready assent to the axiom, "Never allow a rat that can be killed to-day, to live till to-morrow," and we are sure that the author, who has brought experience and judgment to the task of reducing rats, has much good advice to offer, which those who are suffering from the depredations of these rodents cannot afford to neglect.

Readers of "*Das Kalkbrennen*" will very quickly understand how it is that the publishers could, in 1924, risk a second edition of a volume on lime burning, which saw its first edition in 1916. The book of over 500 pages, with 270 illustrations [Leipzig: Otto Spamer; price 25 gold marks], by Mr. Berthold Block, a Berlin engineer, is very instructive. It pays "particular regard to shaft kilns with mixed stone and fuel charges, and to the recovery of the carbon dioxide." The modern lime kiln is steadily reverting to old types, and simple cylindrical shafts are preferred to the complicated improved forms. But the modern lime manufacturer has to combine his kiln with devices for utilising the waste heat and the carbon dioxide. Mr. Block does not suggest doing away with the old approved types, and he does not overlook the fact that uncertain economical conditions in Germany oblige the kiln builder, to make, for instance, the kiln itself of stone again instead of steel. In spite of criticisms of his first edition, he discusses the limestones suitable for burning, in the latter part of his volume—after the general sections on

kilns, fuels, efficiency, draught, gases—because he can then deal with the properties of his raw materials and products together. Chapters on charging and discharging the kilns and on kiln operation follow, and one begins to question the advantage of the sequence, particularly as Mr. Block's own experiments on the proper stratification of rock and fuel in the kiln are given in an earlier part. Mention is made of the unsuccessful attempts at calcining limestone by superheated steam and electric heating; there are hints on the separation of the fuel ashes from the product, but the separation question does not really appear to be discussed. The sections on coke by-products and on gas producers are unnecessary, though the latter lead directly to gas-fired kilns. Non-German literature might have been given more consideration. The two indices contribute to the practical value of this decidedly useful volume.

Professor Eddington's exceptional gifts as an expositor of difficult theories has received a notable recognition by the issue of a French translation of a number of his lectures on the doctrine of relativity. The translation, which bears the title "*Vues Générales sur la Théorie de la Relativité*," is published by Messrs. Gauthier-Villars et Cie, Paris, at the price of 10 francs. The work was undertaken at the instance of certain distinguished French physicists, one of whom, Professor Painlevé, contributes a foreword to the volume, in which he calls attention to the important part played by Professor Eddington in originating the famous solar eclipse expedition to Princes Island in 1919 which definitely showed that rays of light passing near the sun were deflected to the extent predicted by Einstein's theory. Professor Eddington's Royal Institution lecture, delivered in 1918, opens the volume, which also contains his Romanes lecture delivered at Oxford in 1922. This is followed by a note on the mathematical theory of Einstein's law of gravitation. The translation has been made by Dr. Thomas Greenwood, who was formerly a student at the Sorbonne, who has moreover contributed an appreciation of Eddington's work and a short account of the eclipse expedition to which reference has already been made.

In areas where no electric power supply is available, house lighting and power supply for small motors by self-contained electric generating sets is now more and more adopted, and such sets are produced in large quantities by a number of manufacturers. A book on this type of plant is, therefore, a useful and welcome addition to technical literature. Mr. W. Wilson in "*Small Electric Generating Sets*" (Ernest Benn, Limited, London. 18*s.* net) has dealt with his subject in a comprehensive and clear manner. Each item and feature of the combination of oil engine and electric generator with switchboard and battery is dealt with separately, so that the book enables the reader either to study the subject as a whole, or to refer to it for enlightenment on any particular point, on which special information is desired at any time. The development of small self-contained generating sets is principally due to the great strides which have been made in small internal combustion engines due to the perfection of motor car engines, and to the introduction of metal filament and gas-filled lamps, as the low energy consumption of these lamps reduces the size of the plant required, and so the cost of the installation and the running cost, to reasonable figures. The author explains the elementary principles of the various parts, which make up the installation, and describes the various operations required in running. Battery charging which, perhaps, more than anything else is likely to lead to trouble, has received particular attention. These small plants may be classified, according to the automatic features introduced in their working, as (1) non-automatic sets; (2) semi-automatic sets, which need only be started by the attendant, and automatically shut themselves down when the battery is fully charged, and (3) fully automatic sets, where gear is provided to start and stop the set automatically. We feel inclined to agree with the author that the value of fully automatic working has been over-rated, and that the semi-automatic set generally offers the best solution. A point in its favour is the fact that it can be produced at a lower price than a fully automatic set. Where first cost is no consideration, an attendant will usually be available in any case, whilst the man of moderate means will generally prefer to look after the installation himself, so that the additional cost of the fully automatic set is hardly justified. This brings us to the question of the cost of running such sets. The matter is dealt with at the end of the book. We believe, however, it would have been preferable to work out a few examples of this in actual figures based on definite prices of installation, lamps, fuel and maintenance instead of treating the subject mathematically and giving a number of formulæ. The book can be particularly recommended to the growing number of users of self-contained electric lighting plants.

The regular delivery of popular lectures by university professors has been current practice in France, as in other countries, and the advent of broadcasting will doubtless render them available to a wider circle than has been the case hitherto. A scientist who has done excellent work in this connection is Professor A. Turpain, of the Poitiers Science College. His lectures delivered over a course of years in Paris and in several French provincial towns have been printed in five booklets by Messrs. Gauthier-Villars and Co., Paris, at the price of 5 francs each. Their title is "*Conférences Scientifiques*," and they deal with such subjects as electricity, lighting and heating, liquid air and industrial refrigeration, printing and its modern developments, and cinematography, all of which form attractive reading and contain much information. We may here note two points which have struck us more especially. One has reference to the coherer, mentioned in the first book. Professor Turpain records the work of Hughes and other physicists on the electric conductivity of metal filings and adds that the Italian scientist, Calzecchi-Onesti, was the first to make a complete study of the phenomenon in the years 1884 to 1886, and not Mr. Branly, whose work on this particular subject was made known in 1890 and 1891 only, and contained no mention of the fact that the metal filings were sensitive to Hertzian waves. Two others of these books state that the electric incandescent lamp was invented by a French mining engineer named de Changy, and actually made by him in 1858 for the lighting of collieries, whereas the "discovery" by Edison of the incandescent lamp dates from 1877, both lamps being of the same pattern.

Australian Trade Statistics.—The total values of the goods imported to and exported from Australia during the month of November, 1924, were 12,274,505*l.* and 16,536,786*l.* respectively. The exports included produce worth 220,849*l.* which was not of Australian origin.

CONTINUOUS CHART RECORDER.

CONSTRUCTED BY THE FOSTER INSTRUMENT COMPANY, LETCHWORTH.

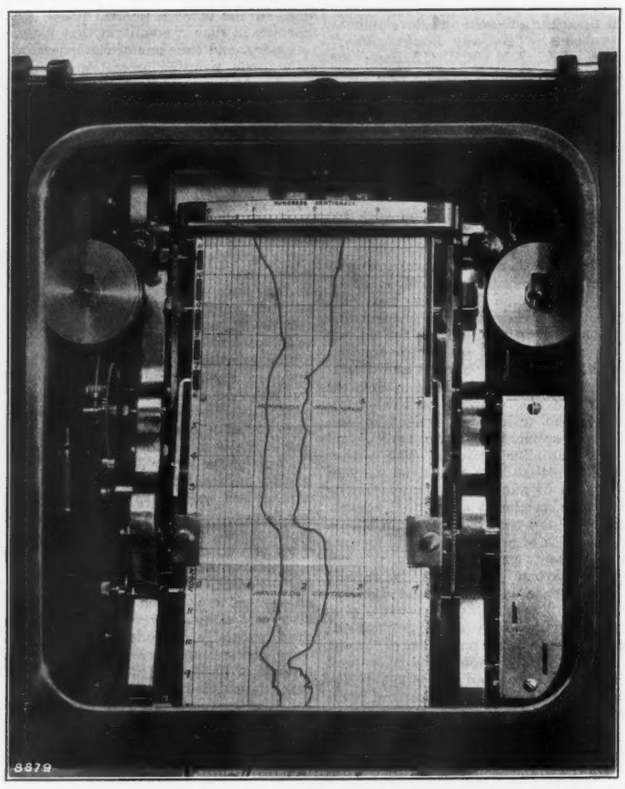


Fig. 1.

THE FOSTER CONTINUOUS CHART RECORDER.

In our account of the recent Physical and Optical Societies' Exhibition we gave, on page 80 of our issue of January 16, a brief description of the continuous chart recorder of the Foster Instrument Company, of Letchworth. The instrument, which combines sensitiveness with the mechanical robustness desirable for industrial pyrometry and similar work, we now propose to describe more fully. The fluctuations of the electromotive forces of pyrometer thermocouples are so weak that difficulties from friction would be likely to arise if the galvanometer boom were in continuous contact with the chart and the record is, therefore, produced in a series of dots on the presser bar principle. By means of an oscillator and an automatic commutator the instrument can further draw two or more records in different colours on the same width of the chart, which is thus fully utilised. The interesting mechanism, by means of which these objects are attained is illustrated in Figs. 1 to 8 on this and the opposite pages.

In Fig. 1 the instrument is seen in its dust-proof metal case, while in Fig. 2 the mechanism is shown separately with the chart roll and ribbon frame canted forward for renewing the chart and ribbon. Both these operations can thus be performed without interference with the galvanometer boom.

The record is formed by the periodical depression of the galvanometer boom by a presser bar operated by clockwork. At the top of the instrument the chart travels over a roller of small diameter, and a knife edge carried by the galvanometer boom is pressed on to the chart above this roller. The effect is practically that of the meeting of two knife edges so that a small dot is produced. The dots are printed by the typewriter ribbon, which is situated between the galvanometer boom knife-edge and the chart. The knife-edge can be seen in Fig. 1 at the top of the left-hand record which is shown on the chart; it can also be seen on the right-hand side in Fig. 2. The presser bar can clearly be seen in Figs. 1 to 3. It is carried on two rocking arms and operated from the clockwork by a connecting link passing down

CONTINUOUS CHART RECORDER.

CONSTRUCTED BY THE FOSTER INSTRUMENT COMPANY, LETCHWORTH.

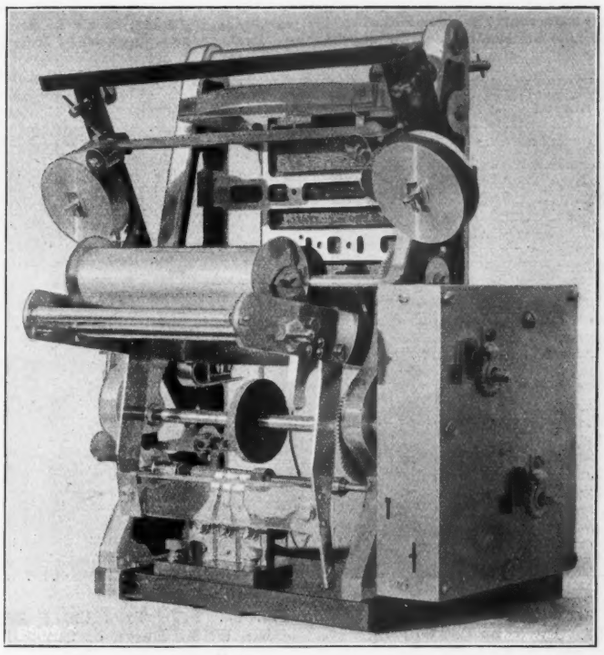


FIG. 2.

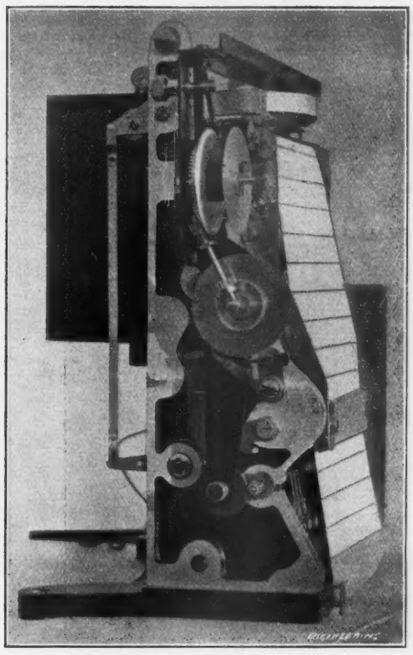


FIG. 3.

Fig. 4.

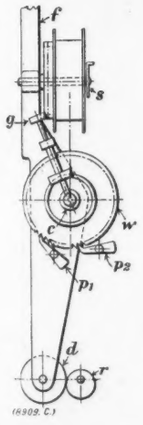


Fig. 5.

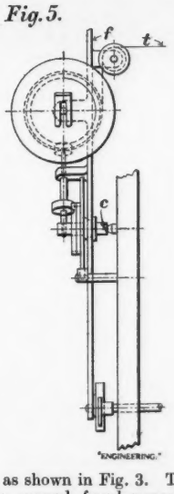


Fig. 6. *Brush Terminals*

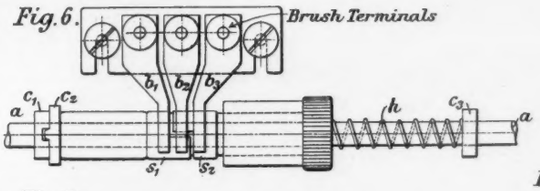


Fig. 7.

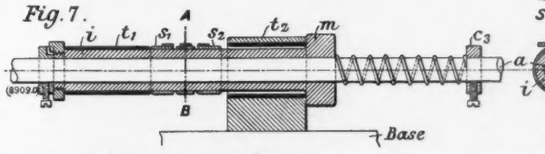


Fig. 8. SEC. A.B.

the back of the instrument, as shown in Fig. 3. This presser bar is formed with a curved faced engraved with a scale reading in degrees centigrade, so that it serves as an indicating instrument, and the position of the galvanometer boom as it swings may be read at any time.

The chart roll is mounted upon a weighted spindle, which normally rests on the friction roller shown as a black disc in Fig. 2 behind the chart roller; this friction roller is positively driven from the clock which controls the time scale. There is a second friction roller in the same plane lower down; it is slightly over-driven and keeps the chart taut. A spring-loaded glass plane, which is best seen in Fig. 3, is pressed against the chart in the neighbourhood of the friction roller.

The typewriter ribbon is very slowly fed forward from the spool on the right over to the spool on the left. The typewriter ribbon is carried by a frame, which runs across the top of the instrument and is clearly shown in Figs. 2 and 3. This frame is continually oscillated by a mechanism which can be seen in in Fig. 3 and in detail in Fig. 4. The frame indicated by f in Fig. 4, is made to oscillate forward and backward through a small angle about the centre c through the intermediation of the disc d and the eccentric roller r at the lower end of the frame. As a result of this oscillation the whole width of the ribbon is usefully employed, and a very slow feed of the typewriter ribbon is further secured by the aid of the ratchet wheel w, the two pawls p_1 and p_2 and the reduction gearing g, which engages with the ribbon spindles. The instrument can produce two records, the ribbon then being in two colours, and the oscillations of the frame f bringing the appropriate colour under the point of contact at the correct moment.

As the instrument is required to draw two curves representing the readings of two pyrometers, a change-over commutator is fitted. This is shown in Figs. 6 to 8. The spindle a is driven by the clock in synchronism with the chart, and controls the periodic depression of the pen for producing the dots. When the recorder is to give one dot per minute alternately upon the two curves of two pyrometer circuits, the spindle is turned at the rate of one revolution every two minutes.

The spindle is furnished with three collars; the collars c_1 and c_3 at the ends of the spindle are fixed, the latter being adjustable, by means of a set screw. The third collar c_2 is fixed to an insulating sleeve i, sliding upon the spindle a. The collar c_2 engages with the collar c_1 through a lug and recess, and the two parts are pressed against one another by the helical spring h. The insulating sleeve further carries the two metallic commutator sections s_1 and s_2, which are stepped and separated by a gap. The three brushes, b_1, b_2, b_3, rest upon the sections, b_1 and b_3 being always in contact with their respective sections, b_2 passing over the gap. Brush b_1 forms part of the circuit of the one thermocouple, b_3 belongs to the circuit of the other thermocouple, while brush b_2 connects the one terminal of the galvanometer alternately with the one or the other circuit; the other galvanometer terminal is joined to the common return lead of the couples.

Owing to the very small voltages produced by thermocouple pyrometers, good contact at the commutator is essential and the arrangement includes a simple and neat cleaning device. The cleaning is effected without dismounting the commutator and interrupting the operation of the recorder for more than a moment or so. The insulating sleeve i carries a tube t_1 made of a fine abrasive, and beyond the commutator sections there is a fixed tube t_2 containing felt or some other cleaning material. When it is desired to clean the contacts, the sleeve i is drawn along the spindle by the milled head m, so that the abrasive tube t_1 passes under the brushes, whilst the commutator sections enter the felt tube t_2. A few partial rotations of the sleeve are sufficient for cleaning the commutator sections and rubbing up the three brushes; the helical spring then forces the sleeve back into its normal position. The brushes are so mounted on an insulating base of the instrument that they can be withdrawn from the instrument if not wanted.

A key projecting from the upper right-hand corner of the case serves for adjusting the zero of the galvanometer boom. The moving system of the instrument is carried by double pivots provided with the "resilia" spring mounting of the firm which we have described on other occasions.

CUTTING TOOLS RESEARCH.

*Report on Flow and Rupture of Metals during Cutting.**

By Walter Rosenhain, B.A., D.Sc., F.R.S., and A. C. Sturney, B.Sc.

(*Concluded from page* 152.)

The "Flow" Type of Chip.—Examples of this type are shown in Figs. 11 to 17. In this case the metal leaves the stock in a ribbon which is more or less unbroken, and the action is, in some ways, analogous to that which occurs during extrusion.

The greatly deformed zone has its boundaries much more clearly defined than in the other types of chip, and this may be due to the predominance of slipping along CD, Fig. 8 (*c*). Measurements made on a number of sections have shown that, in brass, over the range of conditions used, this plane CD makes a constant angle of 60 deg. with the direction of the motion of the tool nose relative to the work, and that the plane CD is at right angles to AB.

The deformed zone is probably identical with the "built up edge on the cutting tool," to which reference has been made by various writers; but microscopic examination and other considerations afford evidence that it is *not* produced "by particles scraped from the work, which form themselves into a solid mass between the work, the chip, and the nose of tool."*

In the first place, although the material in the zone is strongly deformed, the structure is sufficiently well defined to indicate that it has certainly not been formed by the building up of any considerable number of separate particles. The continuity of the metal in this severely deformed zone with the metal of stock and chip, can further be demonstrated by a simple experiment. Annealing causes the rapid re-crystallisation of deformed metal and the re-establishment of normal microstructure (see Fig. 16). It is well known, however, that such a new microstructure is never continuous, that is, the structural constituents do not cross the finest crack nor even the line of a weld. The deformed zone in the present experiments, however, shows after annealing a microstructure perfectly continuous with that of the adjacent metal, thus proving real continuity.

The area of the deformed zone appears to be related to the top-rake angle of the tool. As the top-rake angle is increased, the area of the deformed zone decreases until, with a top-rake angle of 30 deg., it entirely disappears* (see Fig. 17). If this deformed zone consisted of particles scraped from the work, its disappearance when using a tool whose top-rake angle was 30 deg. would be an unexpected coincidence.

The conclusion, therefore, seems to be indicated that the deformed zone is produced by crumpling and deformation of the metal during the first stages of cutting, the amount of such crumpling depending on the top-rake angle of the tool.

The presence of this deformed zone affords an explanation of why, in certain instances, the chip curls. As the developing chip progresses along the plane CD, Fig. 8 (*c*), it eventually meets the top face of the tool, and if this top-rake face is inclined to the direction of motion of the nose relative to the work at an angle greater than that made with the same direction by the plane CD, then the extreme end of the chip will, on contact, be bent upwards. Successively portions of the chip will be bent up to the same extent, so that the whole chip bends upwards, the amount of such curling depending on the top-rake angle of the tool.

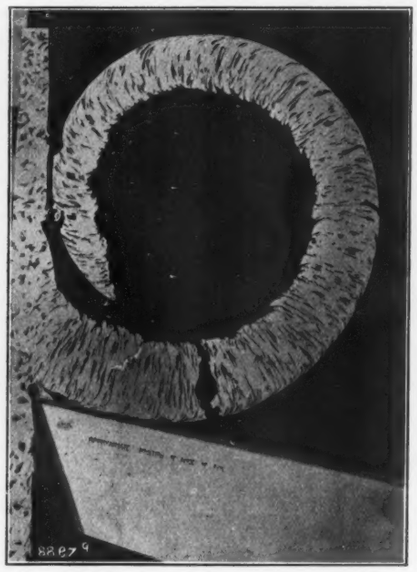


Fig. 11. Flow Type Chip; Mild Steel. No. X.25. Depth of Cut 0·01 In. T.R. 15 deg. × 15 Diam.

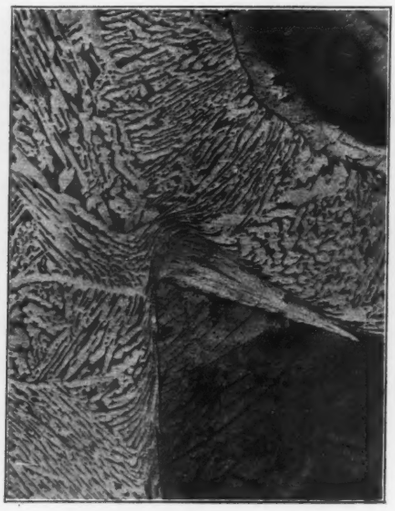


Fig. 14. Flow Type Chip; Brass. No. W.27. Depth of Cut 0·01 In. T.R. 20 deg. × 50 Diam.

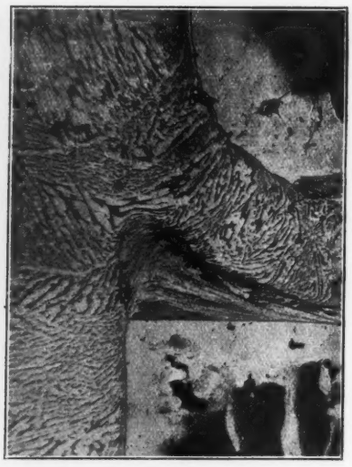


Fig. 15. Flow Type Chip; Brass. No. W.15. Depth of Cut 0·01 In. T.R. 0 deg. × 50 Diam.

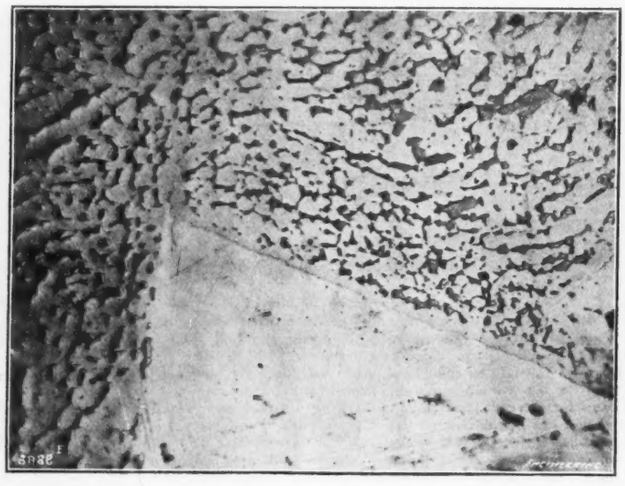


Fig. 16. Flow Type Chip; Brass, after Annealing. No. W.27A. Depth of Cut 0·01 In. T.R. 20 deg. × 120 Diam.

Fig. 17. Flow Type Chip; Brass, showing Disappearance of Deformed Zone. No. VI. Depth of Cut 0·01 In. T.R. 30 deg. × 50 Diam.

* Presented at a meeting of the Institution of Mechanical Engineers, on Friday, January 23, 1925. Abridged.

*Ripper and Burley. Proceedings I. Mech. E., 1913–14, Part 4/1075.

* This only refers to brass.

The shearing of successive portions of the chip along the plane AB, Fig. 8 (*c*), also accounts for a certain amount of bending, so that even with a top-rake angle of 30 deg.,* the chip is not entirely straight, although its radius of curvature is very much greater than when a small top-rake angle is used.

Separation of this type of chip does not generally occur at its root, but at some distance from that point. Rupture is in this case due to the bending action which occurs when the curling chip comes in contact with the uncut surface of the stock.

Reference has already been made to the fact that the character of the chip depends upon the top-rake angle of the tool and on the depth of cut, although other factors which have been kept constant in the present investigation, may also influence the behaviour of the metal. The observations made in the present experiments may be represented graphically on diagrams in which top-rake angle is plotted against depth of cut. This has been done for the results obtained with mild steel in Fig. 18, and with brass in Fig. 19. The areas actually explored are shown by shading, according to the type of chip produced, but the data so far obtained are not sufficient to define the boundaries of these areas more closely. It is probable that if these diagrams were completed, the spaces corresponding to the "flow" and "tear" types of chip would be triangular in form, lying in the right-hand lower and left-hand upper parts of the figure respectively, with a diagonal band, representing "shear" type chips, between them.

SHOWING HOW THE TYPE OF CHIP PRODUCED IS INFLUENCED BY DEPTH OF CUT AND TOP RAKE ANGLE OF THE TOOL.

Fig. 18. STEEL.

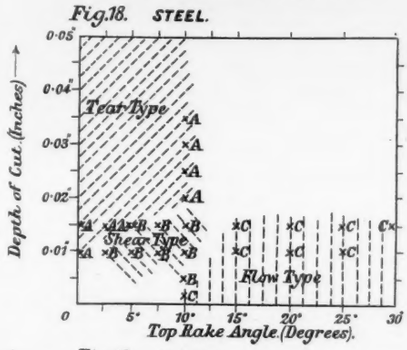
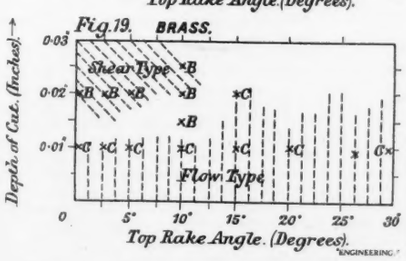


Fig. 19. BRASS.



Two other aspects of the cutting operation remain to be dealt with; namely, the influence of the depth of cut and top-rake angle upon the state of the cut surface, and upon the durability of the tool.

The Influence of Depth of Cut and Top-rake Angle of Tool upon the State of the Cut Surface.—The predominant factor in the formation of the "tear" type of chip is failure of the metal by cracking or tearing in a direction inclined towards the centre of the stock. This is further shown in Fig. 20. This type of cut gives rise to considerable irregularity of surface. This irregularity has been measured under different conditions of cutting. The method used incidentally involved the measurement of the average *actual* depth of cut, and it was found that the latter was not always the same as the *intended* depth of cut as measured by the micrometer feed. Measurements of these variations have also been obtained. The material operated upon was mild steel.

Method of Measuring Depth of Cut.—The general term "depth of cut," in regard to such irregular surfaces may have several meanings. There is first what may be termed the depth of "clear cut"—this is the maximum depth to which all metal has been removed; it corresponds to the tops of the irregularities (as in Fig. 21), and to the diameter as measured on the cut surface by an ordinary micrometer gauge which would rest on the top of the irregularities. There is also a "maximum" depth of cut corresponding to the deepest parts of the irregularities. This is important from the point of view of depth of material disturbed. Finally, there is what may be termed the actual or average depth of cut which corresponds to the volume or weight of metal removed. These have been measured and related to the "intended" depth of cut as determined by the micrometer feed and the actual movement of the tool relatively to the stock. For the purpose of these measurements the cut discs were separately sawn from the main bar, mounted in an enlarging lantern, and the image projected on to a screen, so as to give a magnification of about eight diameters.

The outline was then drawn on paper fixed to the screen. Upon the reproduction thus obtained, the original circumference was reconstructed from the image of an uncut disc or from the uncut arc of the cut disc itself. A portion of such an enlarged drawing is shown in Fig. 21. On such a drawing the area lying between the outer circle AB, and the jagged outline of the cut surface CD, was measured by means of a planimeter for a known length of arc. Such an area, $A = Ld$ where L is the length of the arc and d the difference in radius between the outer circle AB (original surface) and a second circle EF, which represents the average depth of cut. With the radius thus calculated,

Fig. 20.

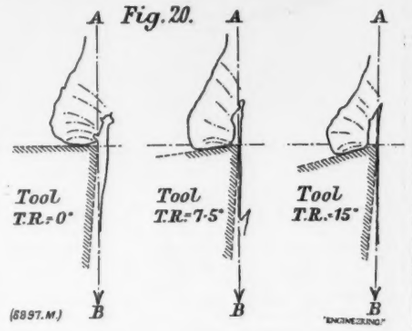
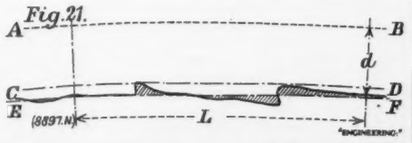


Fig. 21.



the arc of the average depth circle, EF, was drawn on the diagram. From this diagram the various factors above mentioned can be determined. An arc corresponding to the "intended depth of cut" can be readily drawn, and it has been found that this corresponds very closely with the depth of clear cut, *i.e.*, with a circle just enclosing the tops of the irregularities. The average depth of cut is, in certain conditions, where the "tear" type of chip is formed, quite appreciably greater, so that the volume of metal removed is greater than the space swept out by the tool.

A feature of considerable importance is the "degree of irregularity" of the cut surface. This has been measured in terms of cross-sectional area of the irregularities, both above and below the circle of average cut, per unit of length of arc; these areas are shaded in Fig. 21. This represents the "roughness" of the surface. In another sense, the most important feature of the irregularity is the maximum depth of the tears. This is indicated by the difference in each case between "maximum cut" and "average cut," and represents the minimum amount of metal which would have to be removed in a finishing cut. A point of direct practical importance arises here. A rough cut leaving a torn surface will, as the present investigation shows, leave the surface full of minute and very sharp fissures of a nature very likely to initiate cracks. If a finishing cut of sufficient depth is taken, these will be removed, but it may easily happen that at inaccessible points, and especially at re-entrant corners or fillets, the finishing cut may not be taken far enough or deep enough—or the roughing cut may have been taken a little too far. In either case the cutting-tears are left, and a dangerous tendency to crack results. A realisation of these conditions, however, makes the remedy easy to apply, and will, it may be hoped, secure the necessary attention to this point.

Experiments and measurements as described above have been carried out under varied conditions as regards depth of cut and top-rake angle of the tool.

This series of experiments showed:—

(1) That the average depth of cut is greater than the intended depth of cut, and that the excess of the former over the latter increases with depth of cut.

(2) That for a given top-rake angle the degree of irregularity increases proportionally with the depth of cut.

(3) That the average depth of cut is very much greater than that intended when small top-rake angles are used, but decreases rapidly as the top-rake angle increases until, with an angle of about 15 deg., it approximates closely to the intended depth of cut.

(4) That the degree of irregularity varies with the top-rake angle in a manner very similar to the variation of the average depth of cut.

(5) That, so far as observation (3) is concerned, these variations are not accounted for by lack of rigidity in the lathe or by movement of the tool, since the only movements of the tool and test bar recorded tended to diminish rather than to increase the depth of cut.

It has been shown (observations 3 and 4) that the *average* depth of cut reaches a constant value nearly equal to that *intended* when using top-rake angles of 15 deg. or over, and that the degree of irregularity reaches a minimum at that value.

Referring to Fig. 18, it will be seen that, for depths of cut of 0·01 in. and 0·015 in. in mild steel, the transition from the "tear" type to the "flow" type of chip is complete at or about the same top-rake angle. It may, therefore, be inferred that these high degrees of irregularity and abnormal depths of cut are only met with when the tear and shear types of chip are produced, and that, so long as the flow type of chip is formed, whatever may be the values of depth of cut and top-rake angle, the surface will have a minimum irregularity, and that the average depth of cut will not differ sensibly from that intended.

Influence of Depth of Cut and Top-Rake Angle on the Durability of the Tool.—Although no actual tests have been made of the durability of the tool, some of the observations made bear on this question.

(1) In the tear type of chip, the whole of the chip moves outwards relatively to the tool until rupture occurs; then the tool impinges upon fresh metal. This action is likely to result in considerable wear on the cutting edge.

(2) When the flow type of chip is formed, however, the deformed zone, being stationary so far as motion relative to the tool is concerned, acts as a protection to the nose of the tool, and the actual cutting action proceeds from the apex of the deformed zone. So long as the chip continues to come off in a continuous ribbon or breaks at a point distant from its root, the only wear on the tool will occur at a point some distance from the nose. This wear will be greater with small top-rake angles.

(3) If the top-rake angle of the tool is made so large that the deformed zone disappears, the nose will be immediately subject to wear. This confirms theoretically Stanton and Hyde's statement* that "any attempt to reduce the cutting angle appreciably below the limit in the above table (in brass, equivalent to a top-rake angle of about 25 deg.) led either to instability or to immediate blunting of the tool."

So far as the present investigation goes, it indicates that the best results in cutting in regard to the removal of the maximum amount of metal per unit distance of tool travel, the least irregularity of surface, the closest agreement between intended and actual depth of cut, and the minimum wear of tool, are obtained by using a top-rake angle a very little smaller than that at which the heavily deformed zone before the nose of the tool just disappears, in conjunction with the greatest depth of cut which still allows the formation of the "flow" type of chip.

If it can be assumed that the three types of chip which have been studied in this investigation retain their characteristics and mode of formation under different conditions of cutting, it will now be possible, by simply observing the type of chip produced, to determine the effects of varying the speed of cutting, the shape and nature of the tool, and the nature of the metal being cut, as well as the effects of different lubricants and other variables. It is clear, however, that so wide an application of the present method entails much further detailed study.

TRADE IN THE UNITED STATES.—We are informed by the London office of the Guaranty Trust Company, of New York, that the seasonal trade lull in the United States continues, but is becoming less pronounced. Gold exports are still large. The production of pig-iron in December exceeded that for the corresponding period in 1923. The daily average was 95,539 tons, compared with 83,656 tons in November and 94,225 tons in December of the previous year. The output of steel ingots averaged 136,609 tons daily, compared with 124,289 tons daily in November. The maximum monthly output for the year totalled 161,075 tons, registered in March. Unfilled orders of the United States Steel Corporation on December 31, amounted to 4,816,756 tons, compared with 4,031,969 tons at the end of November.

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* This only refers to brass.

* Report to Cutting Tools Research Committee, 1923, page 11.

ALL-STEEL HOUSE CONSTRUCTION.

Among the various methods of steel house construction which have been introduced as a contribution towards the solution of the housing difficulty, the system devised by Mr. J. C. Telford, managing director of Messrs. Braithwaite and Co., Limited, of London, is of much interest. For a house built on this system a concrete platform is laid down after the chosen site has been cleared and levelled. This projects 2 ft. around the space to be occupied by the house, and has a number of rag bolts moulded in it. No metal or wooden framework for the steel walls is required, since these are self-supporting. Roofs, floors, linings, and flues, &c., are all standardised parts, which can be manufactured on mass production lines. The walls are formed of plates pressed in the form of a box and bolted together at turned-in flanges. These plates are each 3 ft. 6 in. in width, and can be conveniently assembled side by side to form a double wall with a 6-in. space between them. When the ground floor sections, with steel window and wooden door frames, have been put together a horizontal connecting-piece is bolted to the sections tying the walls in place at the level of the first floor. Flitch beam supports running the full width of the building can then be raised into position, resting on the horizontal tie, on which arrangement the upper walls, supporting the steel plate roof, are carried. On the outside of the house a special paint of warm stone colour is used, the surface being sanded while the paint is wet. The inner faces of the walls are treated with a bituminous compound. Wooden fillets cover the joints between the metal sections in walls and ceiling and give a panelled effect. Various surfacing materials may be used for the floors as, for example, boards creosoted on the underside and secured in place by means of treated fillets. An interior steel staircase is provided, having wooden treads. The walls are lined on the inside with thick asbestos sheets, secured to a light wooden framework fixed to the metal plates, but separated from them by felting. Cast-iron flues carry away smoke from the grates throughout the house, these flues being enclosed within steel boxes. The heated air inside these boxes is free to circulate within the cavities below the roof and floor, and between the double walls, and tends to maintain an equable temperature. Steel pipes for water, gas, and electric light cables are initially attached to certain sections and only require to be screwed together, as the walls are assembled, to form continuous lengths. It is estimated that a pair of "Telford" parlour-type houses, each containing living room, kitchen, bathroom, scullery and three bedrooms can be erected and finished in eight days at a total cost of 425*l*.

GARDNER COLD-STARTING HEAVY OIL ENGINE.

In the quest for an oil engine, capable of using the cheap crude oils now everywhere available and able to run smoothly and reliably with little attention, and also start easily without the use of any external heating device, the cold-starting type has gradually been brought up to a very high state of efficiency. The use of heavy oils as fuels for internal-combustion engines was not unattended with difficulties. When these problems were solved in an effective way, the power-using public made ever-increasing demands for further economy of operation and facility of starting. Much experimental work had to be done before suitable modifications could be made in the designs to meet the exacting conditions imposed by users, who desired to be completely freed from all the troublesome circumstances previously experienced in getting the engine under way. A modern single cylinder horizontal engine of this type made by Messrs. Norris, Henty and Gardners, Limited, of Barton Hall Engine Works, Patricroft, Manchester, is illustrated on this page and opposite. Fig. 1 shows a general view of an engine of 65–69 brake horse-power, and gives a good impression of its substantial construction. The other illustrations, Figs. 2 to 19, on page 181, give details on the arrangement of the components and indicate the thoroughness with which the various features have been got out.

This engine works on the four-stroke cycle, with solid injection and quantity governing. Not only will the engine start from the cold without any preliminary heating or electric ignition, but it will burn a great variety of fuels, from light high-grade oils to the heavy low-grade types—all, in fact, that might be used for an ordinary Diesel engine. It will be seen, from Figs. 2 and 3, that the cylinder forms a part of the bed structure, which is of the girder type. The cylinder liner is separate from both the cylinder and the breech. It is symmetrical and is held in position without the use of bolts. The joints are made tight against the pressure in the cylinder, and against the water surrounding it in the jackets, by the clamping action of the breech, for which the studs are all external and therefore easily accessible. At the forward end the liner is provided with a composition joint ring. For the breech a water-jacketed casting is used, in which are embodied the combustion chamber, the inlet and exhaust valves, and injection oil sprayer. A large door and several smaller openings are provided on this casting for the examination of the whole of the water-space and the removal of any sediment deposited by the cooling water. The Gardner combustion chamber is constructed with an almost spherical form, opening out through a throat into the conical part forming the cylinder head. As the injected oil passes into this combustion space at the side it has a tendency to take a circular path around the walls. This action is increased by having the throat opening into the combustion chamber tangential to one side, since the stream of air forced into the combustion chamber during the compression stroke has already given the air in it a rotary movement. Intimate mixture of air and oil is thus ensured, and every particle of oil fuel finds its air for rapid combustion. It is understood, of course, that the ignition of the fuel depends solely upon the high temperature to which the air is raised during compression and is not due to contact with any heated surface. Consequently the entire combustion chamber may be water-jacketed.

The piston is ground to size and made of a section of metal diminishing in thickness from front to back, to allow for its varying diametral expansion when at work. This form was determined by long experience, and it is quite unnecessary to resort to easing by hand work. A hollow gudgeon pin of hardened steel is used, and its accommodation within the piston has been studied with a view to preventing any distortion. A solid steel forging is used for the crankshaft. An outer bearing is provided for the extension of the crankshaft beyond the flywheel, its construction being clearly indicated in Fig. 13. Balance weights are fitted, sufficient to counteract the effects of the weight of the crank-pin, web and the proper proportion of the connecting rod. The arrangement of the gear for the operation of the valves is shown in Figs. 4 and 5. This motion is driven from cams on the customary lay shaft, running at half the speed of the engine, since this works on the four-stroke cycle. The form of the fuel injector and sprayer is shown in Fig. 6, while an alternative design used on units of less than 40 h.p. is given in Fig. 18, and the drip-can used with them is illustrated in Fig. 19. Details of the fuel pump and its motion work are shown in Figs. 7 to 9. The control by the governor is arranged to permit variations in the quantity of fuel admitted, in proper relationship to the load on the engine. Whatever changes may be made in the quantity of oil used, the start of injection remains at exactly the same position in the stroke, and consequently there are no irregularities in the combustion, however variable may be the load. The manner in which the governor is used for the control of the quantity of the fuel is indicated in Fig. 8, where a radial arm is shown suspended from a small lever which is varied in position by the motion given to its shaft from the sleeve of the governor. Whatever position the radial arm is in, motion is carried through a bell crank to the pump valve, but the period during which this is held open depends on the position of the radial arm and, therefore, of the governor sleeve at the instant in question. The manner in which the motion is obtained from the sleeve of the governor is indicated in Fig. 10, while Fig. 11 gives details of the type of loaded governor used.

The engine is started from the cold state, without any preliminary heating, by the use of compressed air in the way that is commonly used for modern gas engines. For this purpose an air reservoir is provided and the engine is used for the purpose of recharging this. The starting valve is shown in Fig. 12. As the actual movement of this valve is obtained from a cam on the camshaft it is not possible for the attendant to cause excessive pressures in the cylinder during the starting operations. There are places where very viscous fuels have to be used, in which case, for the first few cycles a lighter oil such as paraffin is injected into the cylinder and provision is made on the standard engine for this purpose.

The crankshaft and the camshaft bearings are of the common ring oiled type, but the cylinder and piston are lubricated by means of accurately measured charges delivered under pressure from a special pump system. This multi-point lubricator is shown in Figs. 15 and 17. It consists of duplex pumps, one pair for each point served, and these are operated by motion obtained from an eccentric on the camshaft. As it is sometimes necessary to give occasional flushes of oil, provision is made by the introduction of a free wheel clutch in the drive (see Fig. 14) so that the lubricator can be operated by hand. In addition to the lubrication of the cylinder and piston, this lubricator delivers oil to the centrifugal oiler for the crank pin (see Fig. 3) and the gudgeon pin, through a pipe running the length of the connecting rod (see Fig. 2).

The engine will run on any fuel that can be used in a Diesel engine. A fuel consumption of from 0·42 to 0·44 lb. per hour per brake horse-power is obtained, depending upon the kind of oil in use. It should be mentioned that the engine illustrated is one of a series of eight standard sizes, the smallest of which is of 15 to 17 brake horse-power and the largest of 78 to 82 brake horse-power.

65-B.H.P. COLD-STARTING HEAVY OIL ENGINE.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, MANCHESTER.

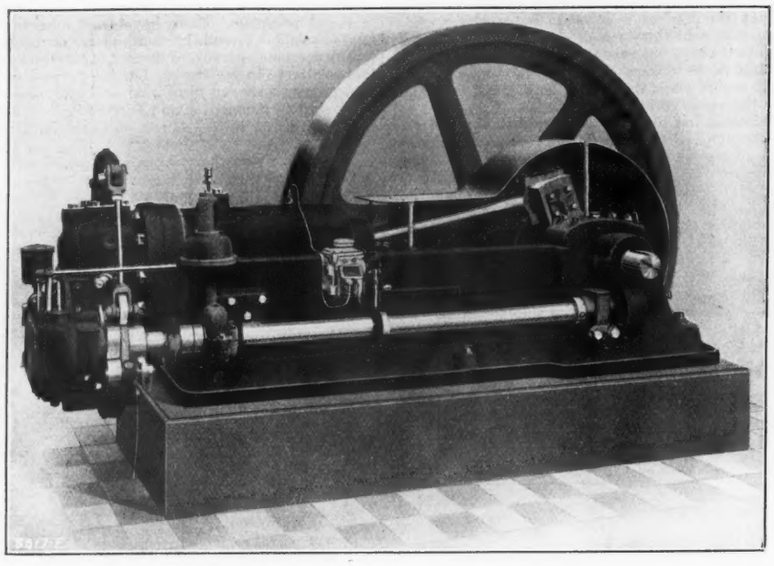


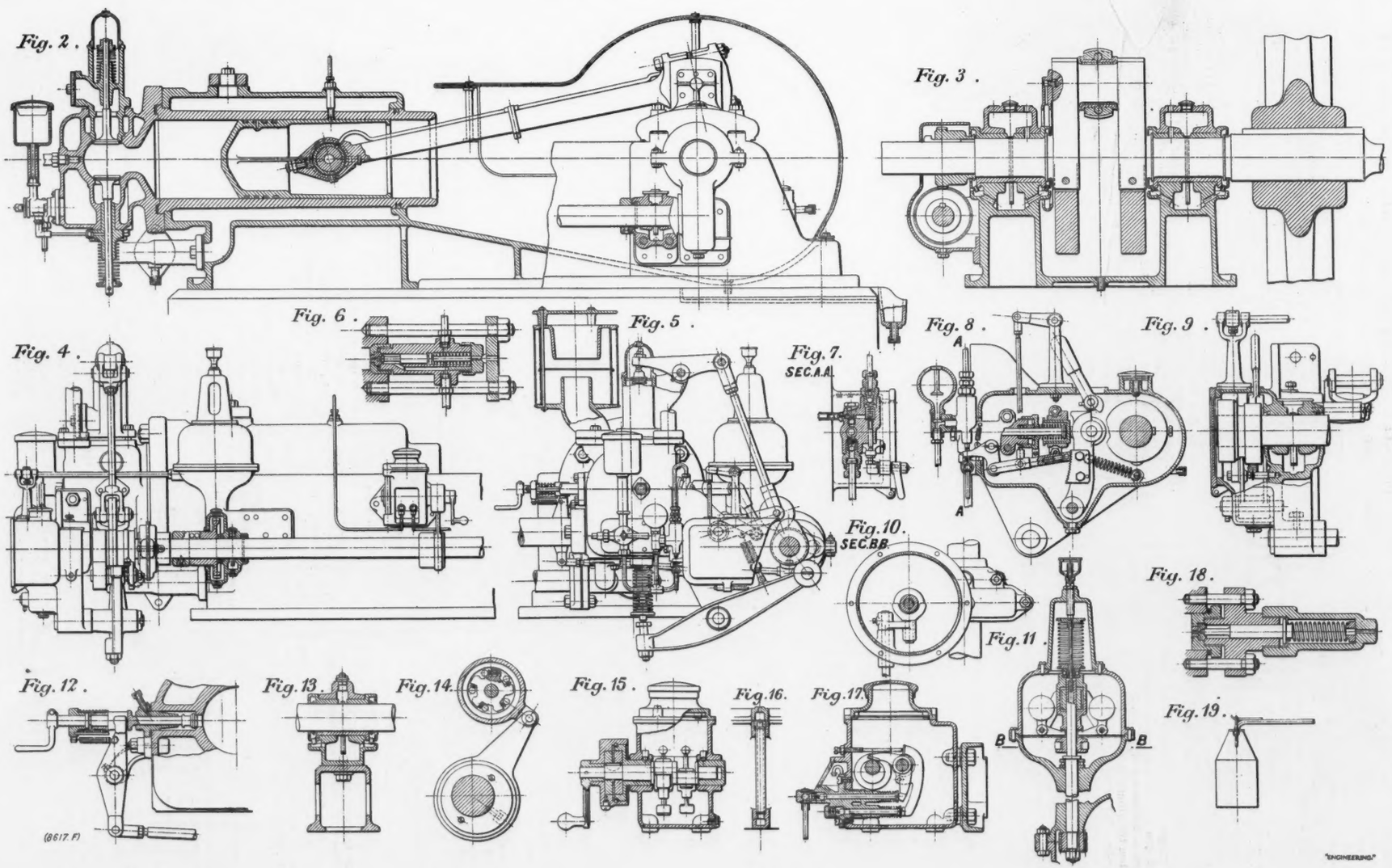
Fig. 1.

The Iron and Steel Institute.—The annual meeting of the Iron and Steel Institute will take place in the hall of the Institution of Civil Engineers on May 7 and 8. The annual dinner wil be held on the evening of Thursday, May 7, at the Hotel Cecil. Further particulars will be issued by the Institute later. The autumn meeting is arranged to take place in Birmingham on Wednesday to Friday, September 9 to 11.

65-B H.P. COLD-STARTING HEAVY OIL ENGINE.

CONSTRUCTED BY MESSRS. NORRIS, HENTY AND GARDNERS, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see opposite Page.*)



"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

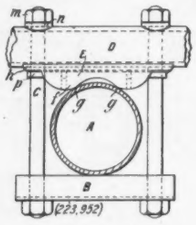
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

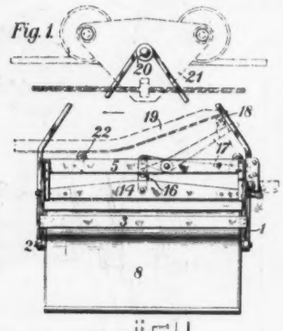
223,952. Edwin Lewis and Sons, Limited, Wolverhampton, and G. A. T. Legg, Wolverhampton. Telephone Poles. (1 *Fig.*) June 30, 1923.—The invention relates to the mounting of tubular pole arms upon steel telegraph poles. A is a telegraph pole formed from a tube. B is the usual back strap and C, C the bolts by which the pole arm D is secured in relation to the pole A. Between the pole arm D and the pole A is placed the usual metal seat E provided on its outer side with a concave cylindrical face to fit against the pole arm and with two flanges *f* on its inner face each so shaped as to bear upon the pole A at two points indicated by the letters *g*, *g*. At each end of the seat E

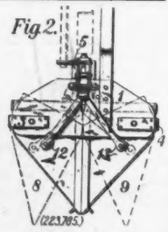


is a lug *h* with a hole through which passes the corresponding bolt C, the bolts serving to keep the seat at the proper height in relation to the pole arm. The bolts are threaded also at their ends to receive nuts *m* and between the nuts *m* and the pole arm D are placed washers *n* with concave faces to fit the curved surface of the pole arm. The bolts also have fixed collars *p*, so that when the nuts at the other end and the back strap are removed, the seat is still retained on the pole arm. In order to remove the seat from the pole arm the nuts *m* must be removed. If desired the bolts C may be screwed down from their ends sufficiently far to allow nuts to be run down and used in lieu of the collars *p*. (*Accepted November* 12, 1924.)

LIFTING AND HAULING APPLIANCES.

223,785. H. A. Sturgess, Croydon, Surrey. Aerial Ropeways. (2 *Figs.*) January 24, 1924.—The invention relates to skips or buckets of the type comprising one or more closing jaws mounted to hinge on a frame and controlling an outlet through which material carried by the skip is discharged down-

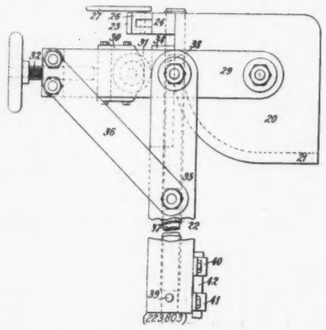




wards. There is also an operating lever pivoted on the frame with link mechanism connecting this lever with the one or more closing jaws. Means of holding the operating lever in its closing position are also furnished. According to the invention, the operating lever is arranged to extend clear of the skip and to be operated, when the closing member or jaws are in the open position, by means disposed in the path of movement of the skip, for the purpose of enabling the operating lever to be actuated automatically, after the skip has been emptied, in order to return the one or more closing members to the closed position. The frame of the skip comprises two end-plates 1, 2 secured together by strap-pieces 3, 4 and a top bar 5. Two scoop-shaped elements 8, 9, each having trunnions which are pivoted in holes in the end-plates 1, 2, are arranged to swing towards and away from one another. The scoops 8, 9 are provided at each end with links 12, 13, which are connected to the ends of a bar 14, which moves vertically. The bar 14 is connected by a link 16 to the operating lever 17. The free end of the lever is provided with a roller 18. When the skip is open the lever assumes the position shown in chain-dotted lines in Fig. 1, in which position, assuming the skip to be travelling in the direction of the arrow, the roller 18 will engage the fixed cam-rail 19; thus, the long arm of the lever will be depressed and the bar 14 will be raised, thus closing the skip by the toggle action of the links 12, 13. To prevent tilting of the skip about its point of suspension 20 from the carriage 21, a roller 22 is provided on the top bar 5 to engage the flat of the cam-rail. (*Accepted November* 5, 1924.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

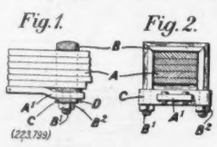
223,803. A. Smallwood, Highgate, London. Bending Tubes. (4 *Figs.*) February 5, 1924.—The invention has for its object the provision of a machine whereby a tube may be bent to any desired curve, without the necessity of employing packing for the inside of the tube whilst it is being bent. A former 20 is mounted in a horizontal plane and is provided with a groove 21 adapted to receive a tube 22. Secured to the former 20 is a bracket 23 carrying a grooved block 24, and a clamping device 26, operated by a handle 27. When the handle 27 is operated, the block 24 is pressed against the tube 22, which is secured to the former 20 in such a manner that it extends therefrom in a tangential direction. Pivoted to the former 20 is an arm 29 carrying a block 30. The block 30 can be made to slide along the arm 29 by a screw 32. 34 is a block provided with a longitudinal groove of corresponding diameter to the groove 21 and pressed into engagement with the tube 22 by the block 34. At right angles to the arm 29 is an arm 35, which acts as a guide member for the tube 22. The arm 35 is braced



to the arm 29 by a link 36. Extending through the tube 22 is a rod 37, the end of which is provided with a curved face 38, the curvature of which is concentric with that of the former 20. The other end of the rod 37 is keyed to the arm 35. The arm 35 is provided with two brackets 40 and 41, adapted to receive a shaft 42 by which the machine may be hand operated. The operation of the device is as follows:—When the tube is clamped to the former 20, and the rod 37 is keyed so that the curved face 38 lies concentric with the curve of the former, with its point of curvature extending slightly beyond the point of pressure of a roller 31 carried by the block 30, if the arm 35 is swung about its pivot, the block 34 will swing about its tangential point, and the roller 31 will travel along the block 34 so as to exert pressure upon the tube 22 as the arms 29 and 35 are rotated. Due to the curved nose 38 on the rod 37, the tube will be bent to any desired arc of a circle, and owing to the pressure with which the tube is pressed into the grooves formed in the former and the block 34, no ripples will be formed upon the inner curved surface of the tube. (*Accepted November* 12, 1924.)

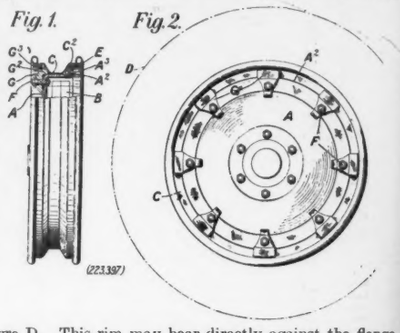
MOTOR ROAD VEHICLES.

223,799. J. C. B. Firth, Sheffield, and J. Wightman, Sheffield. Laminar Springs. (8 *Figs.*) February 20, 1924.—The invention relates to laminar springs intended for use on self-propelled vehicles, and of the kind in which the plates or leaves are surrounded by



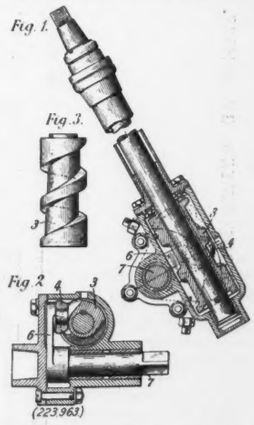
clips or buckles serving to prevent relative lateral displacement between them. According to the invention, the end of one of the flat-leaf springs is turned down, joggled or otherwise shaped and passed through or into a slot or recess in the clip, or the like, or held rigidly between two members forming part of the clip. The leaves A are surrounded by a clip comprising a U-shaped member B provided with a removable bridge-piece C, which is attached to the ends of the limbs of the U-shaped member by studs B^1 and nuts B^2. The bridge-piece C is slotted to receive the joggled end A^1 of the lowest flat leaf, which projects through the slot. Pins D are conveniently passed through holes formed in the end A^1 of the spring which projects through the slot. These pins are not intended to take any stress during the operation of the spring, but are primarily to prevent rattle or shake. (*Accepted November* 5, 1924.)

223,397. J. D. Siddeley, Coventry. Motor Vehicle Wheels. (2 *Figs.*) October 11, 1923.—The invention relates to wheels of the kind with which is used a rubber, and preferably a pneumatic, tyre and to which is fitted a brake. According to the invention, the tyre is mounted upon a rim, which is detachably fixed to the outer periphery of a brake drum. The drum is of large diameter and comprises the usual disc A, the edge A^2 of which is turned parallel to the axis to form the drum against the interior of which the shoes B of the brake take effect. The unsupported edge A^3 of the drum is flanged radially outwards. Upon the outer periphery of the drum is slipped a channel section rim C carrying the



tyre D. This rim may bear directly against the flange A^3, but, preferably, there is an intermediate packing ring E of a section to fill up the corner formed by the flanges A^2, A^3 of the drum and the underside of the channel and/or the clinch C^2 of the rim. The rim is held in place and forced towards the flange A^3 by clamps G mounted on studs F. The outer edges of the clamps are arranged to bear against the side of the rim and are shaped at G^2 to fit upon the outer periphery of the drum and at G^3 to fit under the corresponding edge of the rim so as to create a slight wedging action which locks the rim and the clamps or ring tightly.—(*Sealed.*)

223,963. R. Bishop, Golders Green. Steering Gear. (3 *Figs.*) July 25, 1923.—The invention has relation to gearing of the kind comprising a cam constituted of a worm fixed on an operating shaft and engaged by a roller mounted on an arm so as to be substantially at right angles thereto, the arm, in turn, being mounted so as to be movable angularly and in a plane that is substantially parallel to the longitudinal axis of the worm, the roller through its mounting co-operating with other members of the gearing. In gearing of the kind referred to, in accordance with the invention, a cam 3 approximating a worm of constant diameter is engaged by a pin or roller 4 mounted on an arm 6 that is angularly movable in a plane parallel to the longitudinal axis of



the cam 3. The arm is mounted on a rocker shaft 7 and the axes of the arm and of the pin or roller are at right angles. The cam is produced by subjecting the cam blank to the action of a fixed tool whose operative edge or face is at the same angle as the face of the roller, the cam blank being rotated about its axis and at the same time moved in the arc of a circle whose radius is equal to the length of the roller-carrying arm between the centre of the rocker shaft and the axis of rotation of the roller. This movement is effected without any change in direction of the longitudinal axis of the cam blank, so that the depth of the cam groove varies to enable it to co-operate with the said pin or roller at all times and without lost motion. (*Sealed.*)